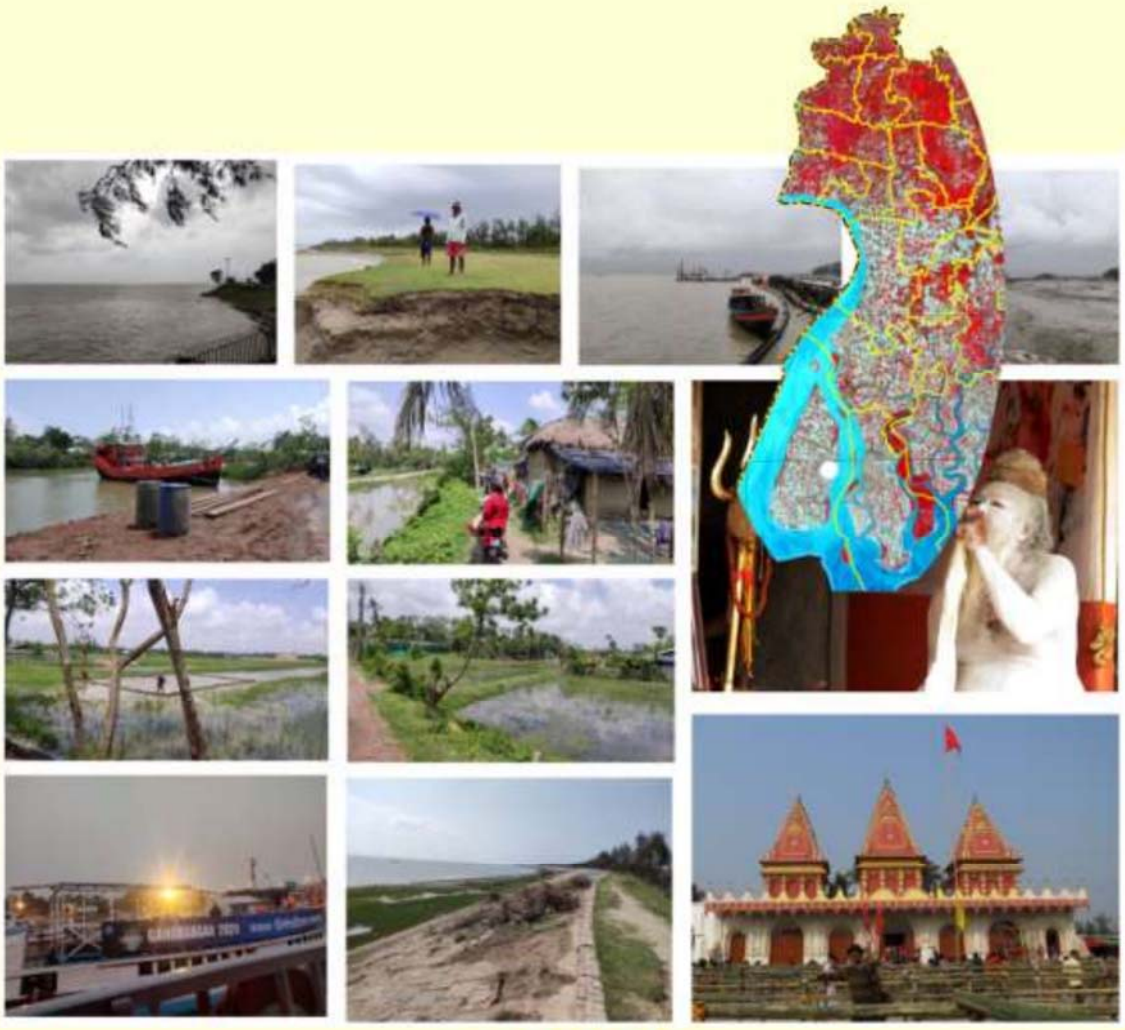
SOUTH 24 PARGANAS

DOCUMENTATION OF GANGA FROM GOMUKH TO GANGASAGAR



NAMAMI GANGE

Report submitted by:

The Natural Heritage Division

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ABBREVIATIONS

AISLUS	All India Soil & Landuse Survey
As	Arsenic
ASI	Archaeological Survey of India
BGL	Below Ground Level
BOD	Biochemical Oxygen Demand
CGWB	Central Ground Water Board
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPT	Calcutta Port Trust
DEM	Digital Elevation Model
DO	Dissolve Oxygen
DPMS	District Planning Map Series
DWF	Dry Water Flow
E-Waste	Electronic Waste
EC	Electrical Conductivity
EKW	East Kolkata Wetlands
EMP	Environmental Management Plan
ETM	Enhance Thematic Mapper
FCC	False Colour Composite
GAP	Ganga Action Plan
GCP	Ground Control Point
GIS	Geographic Information System
GOI	Government of India
GoWB	Government of West Bengal
GPS	Global Positioning System
GSI	Geological Survey of India
HWL	High Water Level
IMD	Indian Meteorological Department

INTACH	Indian National Trust for Art & Cultural Heritage
IWMED	Institute of Wetland Management & Ecological Design
K	Potassium
KEIP	Kolkata Environment Improvement Project
KIT	Kolkata Improvement Trust
KMA	Kolkata Metropolitan Area
KMC	Kolkata Municipal Corporation
KMDA	Kolkata Metropolitan Development Authority
LULC	Landuse Land cover
LWL	Low Water Level
MSL	Mean Sea Level
MSS	Multi Spectral Scanner
MWL	Mean Water Level
N	Nitrogen
Na	Sodium
NATMO	National Atlas & Thematic Mapping Organisation
NBSS&LUP	National Bureau of Soil Survey & Landuse Planning
NDVI	Normalised Differential Vegetation Index
NH	Natural Heritage
NMCG	National Mission for Clean Ganga
NTFP	Non Timber Forest Product
pH	Hydrogen Ion Concentration
PPT	Precipitation
RF	Rainfall
RGB	Red Green Blue
RS	Remote Sensing
SPM	Suspended Particulate Matter
SRTM	Shuttle Radar Topographic Mission
SWID	State Water Investigation Directorate
TM	Thematic Mapper

UNDP	United Nations Development Programme
USGS	United Nations Geological Survey
WBPCB	West Bengal Pollution Control Board
WF	Wetland Fauna

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Chapter 1: Introduction

1.1.Background of the Project

Namami Gange Programme', is an Integrated Conservation Mission, approved as 'Flagship Programme' by the Union Government in June 2014 with the twin objectives of effective abatement of pollution, conservation and rejuvenation of National River Ganga.

1.1A. Key achievements under Namami Gange programme:

a. **Creating Sewerage Treatment Capacity:-** 63 sewerage management projects under implementation in the States of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal.12 new sewerage management Projects Launched in these states. Work is under construction for creating Sewerage capacity of 1187.33 (MLD).Hybrid Annuity PPP Model based two projects has been initiated for Jagjeetpur, Haridwar and Ramanna, Varanasi.

b. **Creating River-Front Development:-**28 River-Front Development projects and 33 Entry level Projects for construction, modernization and renovation of 182 Ghats and 118 crematoria have been initiated.

c. **River Surface Cleaning:-**River Surface cleaning for collection of floating solid waste from the surface of the Ghats and River and its disposal are afoot and pushed into service at 11 locations.

d. **Bio-Diversity Conservation:-** Several Bio-Diversity conservation projects are namely: Biodiversity Conservation and Ganga Rejuvenation, Fish and Fishery Conservation in Ganga River, Ganges River Dolphin Conservation Education Programme has been initiated. 5 Bio-Diversity center's at Dehradun, Narora, Allahabad, Varanasi and Barrackpore has been developed for restoration of identified priority species.

e. **Afforestation:** Forestry interventions for Ganga through Wildlife Institute of India; Central Inland Fisheries Research Institute and Centre for Environment Education has been initiated. Forestry interventions for Ganga have been executed as per the Detailed Project Report prepared by Forest Research Institute, Dehradun for a period of 5 years (2016-2021) at project cost of Rs.2300 Crores. Work has been commenced in 7 districts of Uttarakhand for medicinal plants.

f. **Public Awareness:** A series of activities such as events, workshops, seminars and conferences and numerous IEC activities were organized to make a strong pitch for public outreach and community participation in the programme. Various awareness activities through rallies, campaigns, exhibitions, *shram daan*, cleanliness drives, competitions, plantation drives and development and distribution of resource materials were organized and for wider publicity the mass mediums such as TV/Radio, print media advertisements, advertorials, featured articles and advertorials were published. Gange Theme song was released widely and played on digital media to enhance the visibility of the programme. NMCG ensured presence at Social Media platforms like Facebook, Twitter, YouTube etc.

g. **Industrial Effluent Monitoring:** The number of Grossly Polluting Industries (GPIs) in April, 2019 is 1072. Regulation and enforcement through regular and surprise inspections of GPIs is carried out for compliance verification against stipulated environmental norms. The GPIs are also inspected on annual basis for compliance

verification of the pollution norms and process modification, wherever required through third party technical institutes. First round of inspection of GPIs by the third-party technical institutes has been carried out in 2017. Second round of inspection of GPIs has been completed in 2018. Out of 961 GPIs inspected in 2018, 636 are complying, 110 are non-complying and 215 are self-closed. Action has been taken against 110 non-complying GPIs and is issued closure directions under Section 5 of the E (P) Act. Online Continuous Effluent Monitoring Stations (OCEMS) connectivity established to CPCB server in 885 out of 1072 GPIs.

h. **Ganga Gram:** Ministry of Drinking Water and Sanitation (MoDWS) identified 1674 Gram Panchayats situated on the bank of River Ganga in 5 State (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal). Rs. 578 Crores has been released to Ministry of Drinking Water and Sanitation (MoDWS) for construction of toilets in 1674 Gram Panchayats of 5 Ganga Basin States. Out of the targeted 15, 27,105 units, MoDWS has completed construction of 8, 53,397 toilets. Consortium of 7 IITs has been engaged in the preparation of Ganga River basin Plan and 65 villages have been adopted by 13 IITs to develop as model villages. **UNDP** has been engaged as the executing agency for rural sanitation programme and to develop Jharkhand as a model State at an estimated cost of Rs. 127 Crore.

National Mission for Clean Ganga (NMCG) endeavors to deploy best available knowledge and resources across the world for Ganga rejuvenation. Clean Ganga has been a perennial attraction for many international countries that have expertise in river rejuvenation. Countries such as Australia, United Kingdom, Germany, Finland, Israel etc. have shown interest in collaborating with India for Ganga rejuvenation. Memorandums of Understanding (MoUs) were signed with various Central Ministries viz.- Ministry of Human Resource Development, Ministry of Rural Development, Ministry of Railways, Ministry of Shipping, Ministry of Tourism, Ministry of Ayush, Ministry of Petroleum, Ministry of Youth Affairs and Sports, Ministry of Drinking Water & Sanitation and Ministry of Agriculture for synergizing the Government schemes.

1.1B. Why we need "Namami Gange" programmes:

a. River Ganga has significant economic, environmental and cultural value in India.

b. Rising in the Himalayas and flowing to the Bay of Bengal, the river traverses a course of more than 2,500 km through the plains of north and eastern India.

c. The Ganga basin - which also extends into parts of Nepal, China and Bangladesh - accounts for 26 per cent of India's landmass.

d. The Ganga also serves as one of India's holiest rivers whose cultural and spiritual significance transcends the boundaries of the basin.

1.1C. Aim & Objective of NMCG

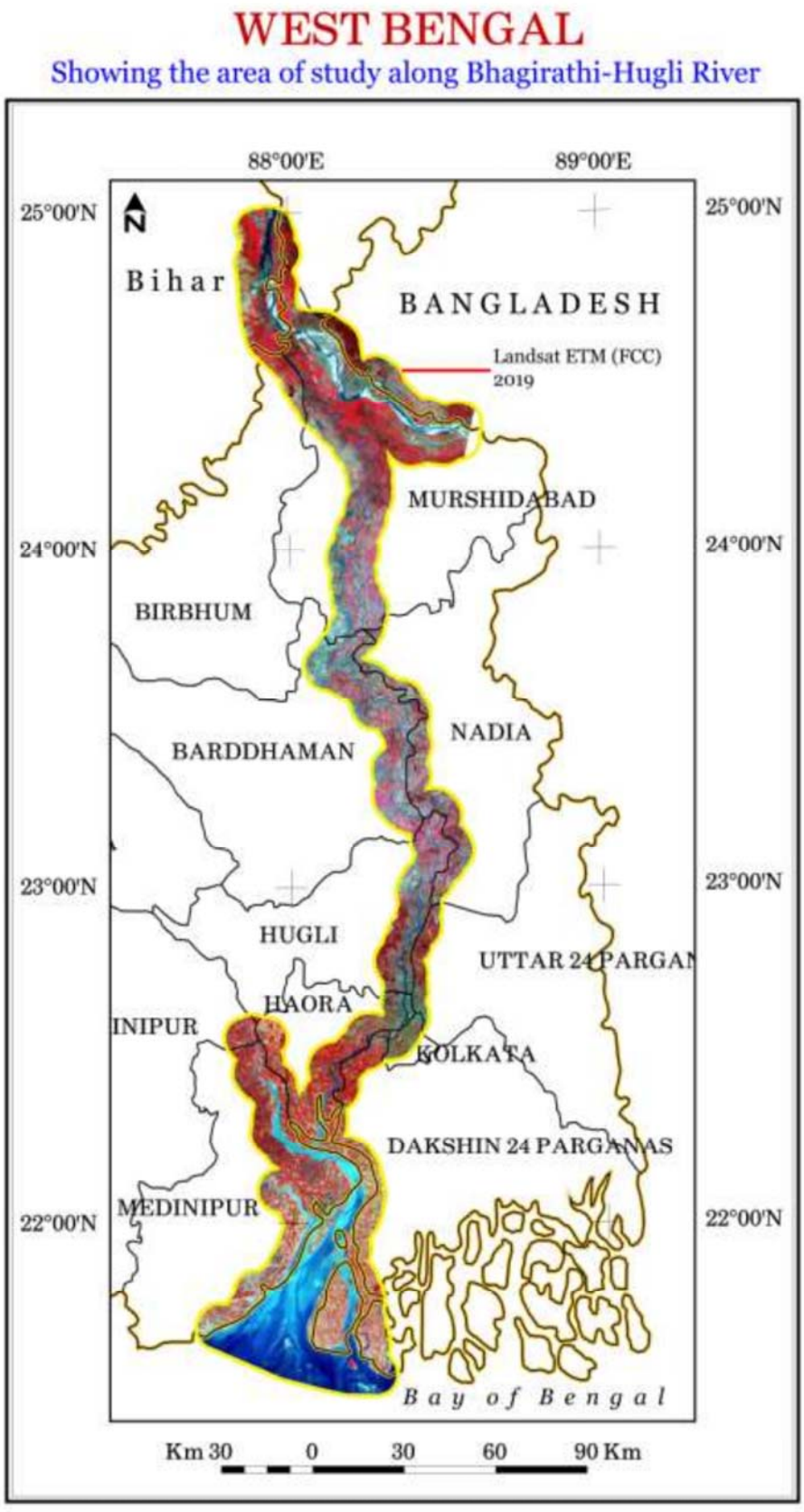
The aims and objectives of NMCG are to accomplish the mandate of National Ganga River Basin Authority (NGRBA) are:

1. To ensure effective abatement of pollution and rejuvenation of the river Ganga by adopting a river basin approach to promote inter-sectoral co-ordination for comprehensive planning and management and
2. To maintain minimum ecological flows in the river Ganga with the aim of ensuring water quality and environmentally sustainable development.

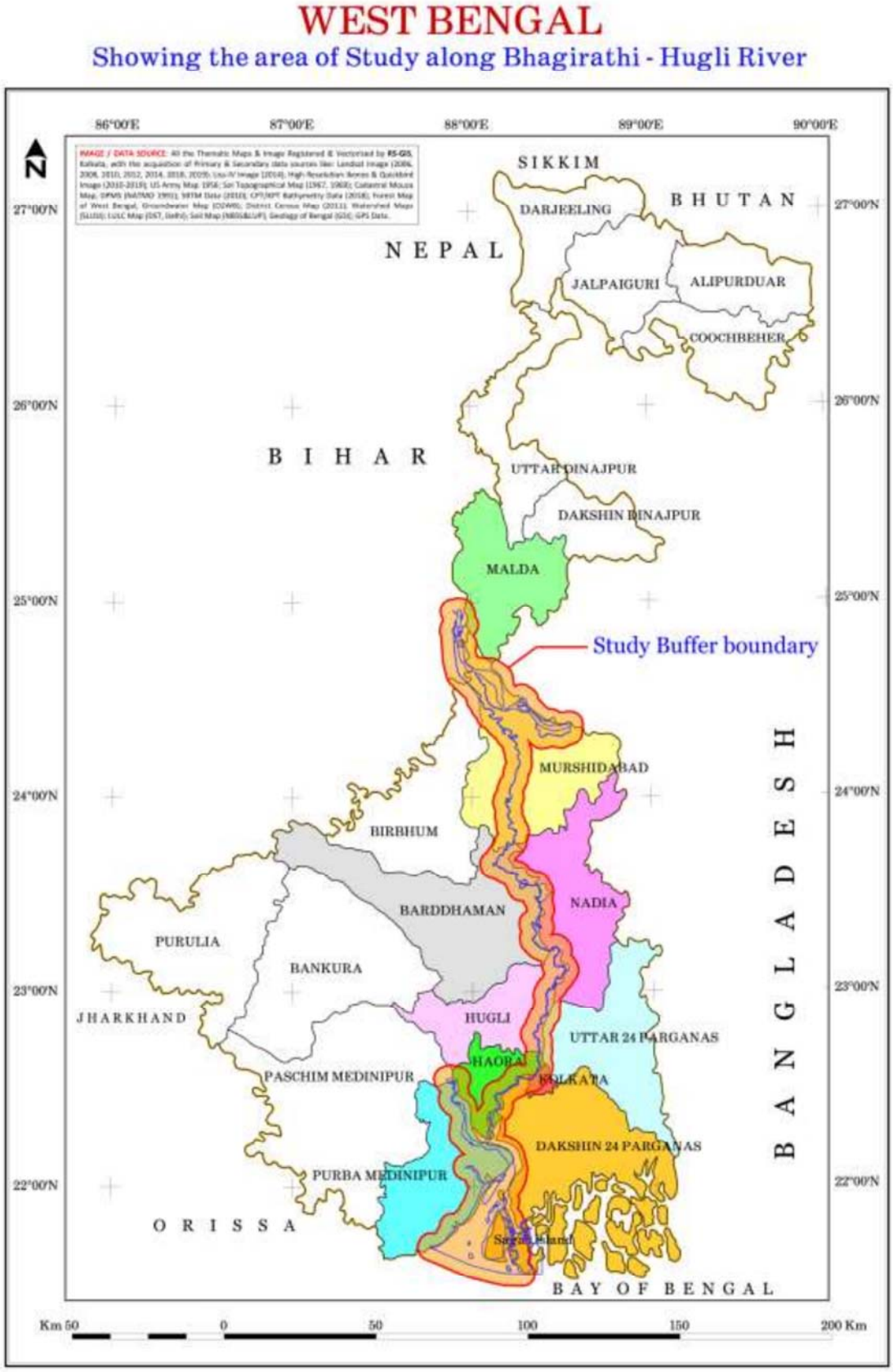
1.2. GANGA CULTURAL DOCUMENTATION

India is endowed with rich water resources with approximately 45,000 km long riverine systems criss-cross the length and breadth of the country. The Ganga river basin is the largest of the basins of India with an area of 8,61,452 Sq.km in India, draining into the 11 states of the country, Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh and West Bengal. The Ganga river has many tributaries, both in the Himalayan region before it enters the plains at Haridwar and further downstream before its confluence with the Bay of Bengal. The basin has a total drainage length of about 624235.73 Sq.km. The Ganga basin lies between east longitudes 73°2' to 89°5' and north latitudes 21°6' to 31°21' having maximum length and width of approx. 1,543 km and 1024 km. The average water resource potential of the basin has been assessed as 525020 Million Cubic Meters (MCM).

Sl.	Head Details			Quantitative Information		Remarks
1.	State Name: West Bengal			-	-	
2.	Geographical Extension of Bhagirathi-Hugli			N N	E E	
3.	Areal coverage in 5km Buffer					
4.	Areal coverage in 10km Buffer					
5.	Total Number of Districts coverage			10		
6.	District wise Police Station & Ward coverage	**District**		Number of PS/ Wards	Length of Hugli River	
		A	Malda	04	88 Km	
		B	Murshidabad	13	520 Km	
		C	Nadia	09	112 Km	
		D	Barddhaman	04	138 Km	
		E	Hugli	09	91 Km	
		F	Haora	09	69 Km	
		G	North 24 Parganas	09	42 Km	
		H	South 24 Parganas	09	110 Km	
		I	Kolkata	144 Wards	20Km	
		J	Purba Medinipur	06	92 Km	
7.	Total Length of the Bhagirathi-Hugli River in the Lower Part			1282 Km.		



Map 1 – Map of West Bengal showing the study area



Map 2 - Map of West Bengal showing the overall location of the Study area.

1.3. Documenting Natural Heritage & Ecological Interdependencies

Natural Heritage would not replicate the work of scientific institutions Biodiversity Conservation is being studied and implemented by Wildlife Institute of India to cover Golden Mahseer, Dolphins, Crocodiles, Turtles and Otters and other fauna under conservation programme. These studies would be referred to.

1.3A. Changes in Flows, Water Levels: The documentation of natural heritage at several sites and banks will look at the changes in flows, earlier course of the river if any and observable changes in water level as revealed in discussions with resource persons and local communities.

1.3B. Floodplains Crops and natural riparian flora and fauna, ox-bow lakes would be recorded

1.3C. Species-Fauna, Flora, Birds and others: Observations of riparian communities regarding changes in flora and fauna both riparian and in-stream would be recorded

1.3D. Sacred Groves: Landscapes that have both ecological and religious significance, where religion has ensured conservation of natural landscapes shall be noted

1.3E. Sacred Species: Certain species and specific trees are considered sacred because of associated religious beliefs or biological significance. It is because of their presence that several landscapes and sites stand safe. Many of these trees have a close association with the river during performance of some rituals. For instance, Bhojapatra is a birch tree native to the Himalayas, growing at elevations up to 4,500 m. The specific epithet, *utilis*, refers to the many uses of the different parts of the tree. The white, paper-like bark of the tree was used in ancient times for writing Sanskrit scriptures and texts. It is still used as paper for the writing of sacred mantras, with the bark placed in an amulet and worn for protection. In the sacred forests of Bhojwasa, around Gaumukh, such forests have been protected by pilgrims and resident communities, for eons.

1.3F. Community Understanding of Riparian Rights: Several communities, like the fishermen of the lower delta regions, have been caught in conflict with incumbent authorities in British and Independent India over riparian rights. The project aims to develop an understanding of what constitutes community riparian rights and whether communities are in conflict with authorities over the same.

1.3G. Confluence Points: The course of the Ganga is dotted with several confluence points of lower order streams which will be marked geospatially to understand the catchment and wider system of this river. The documentation also aims to name the minor tributaries that flow within this system and join it at various places.

1.3H. Review of Scientific Research on the Waters: Many scientific papers have been published on the Ganga and features of its water that keep it free of decay. These papers will be referred to recording what they suggest in terms of keeping the waters pristine.

1.4. METHODOLOGY

1.4A. Capacity Building:

a. **Training arrangement:** Two phases of training have given to the Field Coordinators, Field survey staff and the Project Resource persons. First phase of training has conducted by the Project Funding Authority i.e. INTACH, Delhi and second phase of training will be conducted by the Project Implementing Agency i.e. RS-GIS, Kolkata.

b. **Development of Project Team:** A Project team has formed according to the need of the objective of the present Project. It is formed headed by the coordinator and the Social Scientist. Other members of the Project team are the GIS-Remote Sensing Expert, Field assistant (Geography background), Local Resource persons, Camera person and Hydrologist, Soil Scientist, Botanist, Zoologist & Agriculture scientist.

c. **Acquisition / Procurement/ Purchase of Gadgets /Equipments / Analysis:** Following Gadgets/Equipments have been purchased for the implementation of the Project work: GPS machine, Satellite Image (Two seasons, Recent Data), Soft / hard copy Cadastral maps, Soil / Water storage Kit, Measuring Tape/ Compass/ Dumpy level, Topographical / DPMS, Laboratory Test / Analysis, procurement of other secondary Data / Information / Maps from Census, Irrigation, Ground water, Soil, Agriculture, Forest etc. Purchase of Books, Reproduction of Survey formats & Stationeries etc.

1.4B. Pre-Field Survey:

a. **Literature review:** Library work, Study of published and unpublished reports, News paper articles, Journals and Research papers.
b. **Collection of Secondary Data/ Information (Maps) from Govt. Departments:** GSI, NATMO, CGWB, NBSS & LUP, IMD, SWID, PHED, KMC Office, Survey of India (SoI), KOPT, West Bengal Fisheries Corporation, Irrigation & Waterways GoWB, West Bengal Forest Deptt. PWD, Census of India, AISLUS etc.
c. **Satellite Data Acquisition (Real-time):** NRSA Hyderabad, University of Calcutta (Deptt. of Geography), USGS Earth Explorer.
d. **Base-Map Preparation** (for whole Project area)**:** Consulting Topographical maps, Census maps, DPMS & Recent Multi spectral Satellite Image.

1.4C. Field Survey:

a. **Data-Information Collection & Measurements:** Collection of detail information with GPS locations, related to- Surface Morphology /Relief/ Physiography, Geology, Climatic conditions, Bank erosion, Embankment condition, Depth of river Bhagirathi-Hugli, Shifting river course and Paleo-channels, Status of Confluence and Off-take points of rivers, Canals, Flood events and Tide levels, Heritage water structures, Wetlands, Ground water regime, Soil, Water quality, Riparian Flora-Fauna, Sacred trees, Landuse-Land cover types, Impact of Dams/Barrages/Mining, Utilization of Flood plain, Riparian Rights etc.

b. **Photo & Videogrpahy:** Professional photographers having enough experience of Physical, Social, Ecological & Environmental issues will be engaged for Digital documentation of different events related to the Natural phenomenon.

1.4D. Post Field Analysis:

a. **Collection & Scrutinization of Field Data/Survey sheets:** Region / Block/ PS/ Mouza wise *Proforma for Listing the Natural Heritage* survey sheets will be checked / verified with the concern persons.

b. **GPS Data analysis:** Collecting the Ground Control Points (GCP's) & GPS-Tracks of Land surface & Waterbodies, the database will be processed through Map-Source Software

c. **Water & Soil Sample data analysis:** Sample will be supplied for analysis in reputed Govt. Departments or Private agencies.

d. **Preparation of Theme Maps:** Location, Administrative, Relief, Geology, Geomorphology, Drainage, Waterbody, Canals, Groundwater, Soil, Rainfall-Temperature, Vegetation, Tidal fluctuations, Landuse-Land cover, Shifting of Rivers, Embankment status, Population growth, Flood condition, Watershed divisions, GPS locations of specific units, Urbanization level etc.

1.4E. Validating Field & Analised Data:

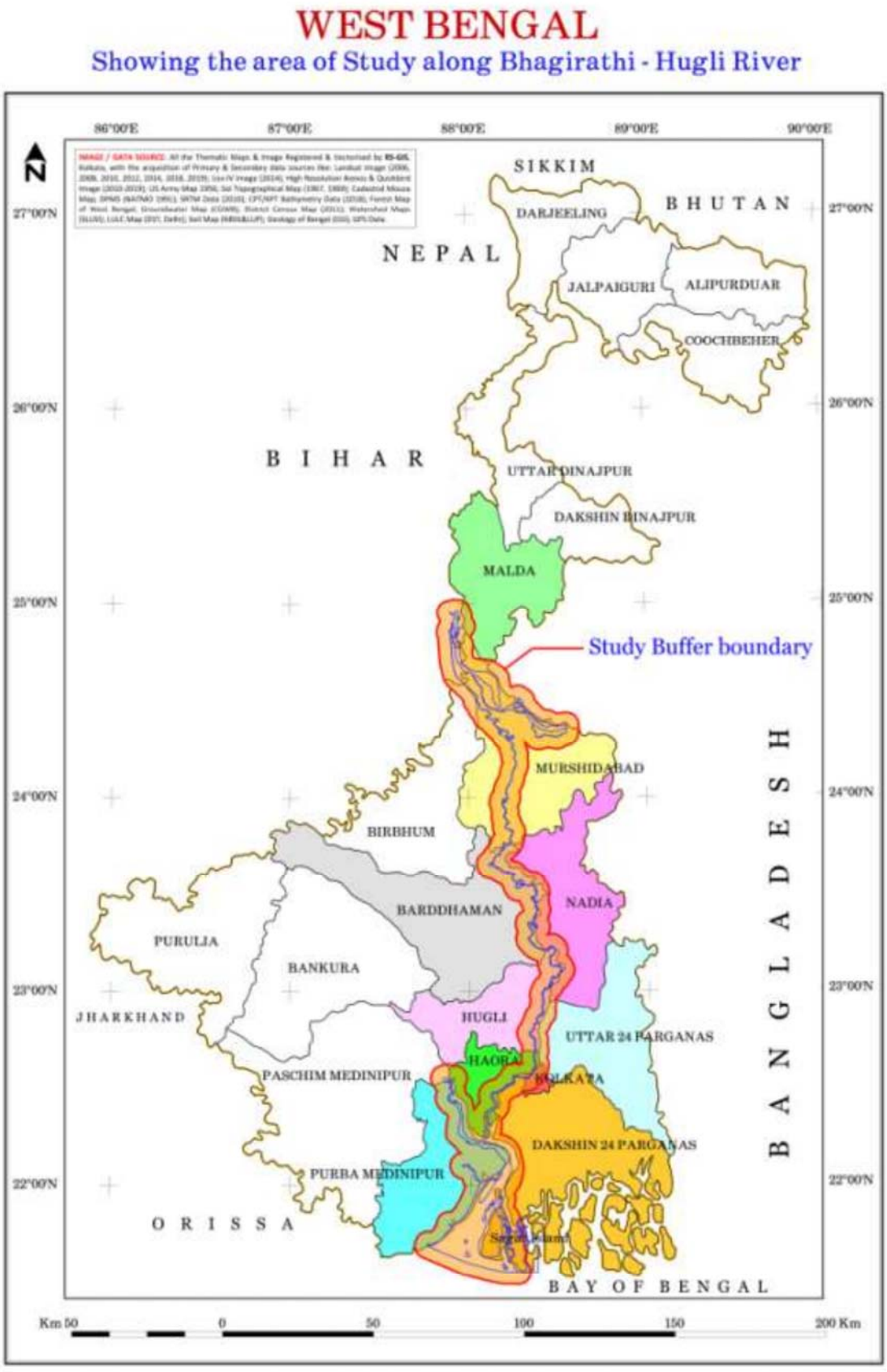
a. **Landuse Land cover units:** Physical & Cultural units on land surface to be verified after revisit the area with recent Satellite Image.
b. **GPS locations:** After Overlaying the data on Satellite Image (Google Earth Image) Cross-checking will be done
c. **Water Sample analysis data:** COD, BOD, pH, EC, DO, Turbidity analysis of Water samples.
d. **Flora/Fauna:** Riparian, Sacred Species with their environment.

1.4E. Preparation & Submission of Report

a. **Preparation of Draft Report:** Preliminary Draft Report in Soft & Hard copy mode (1 Colour Printed) of each District will be submitted to INTACH, Kolkata Convener for Verification / Correction

b. **Report Correction:** Any corrections made by the funding authority will be incorporated judiciously into the Final Report.

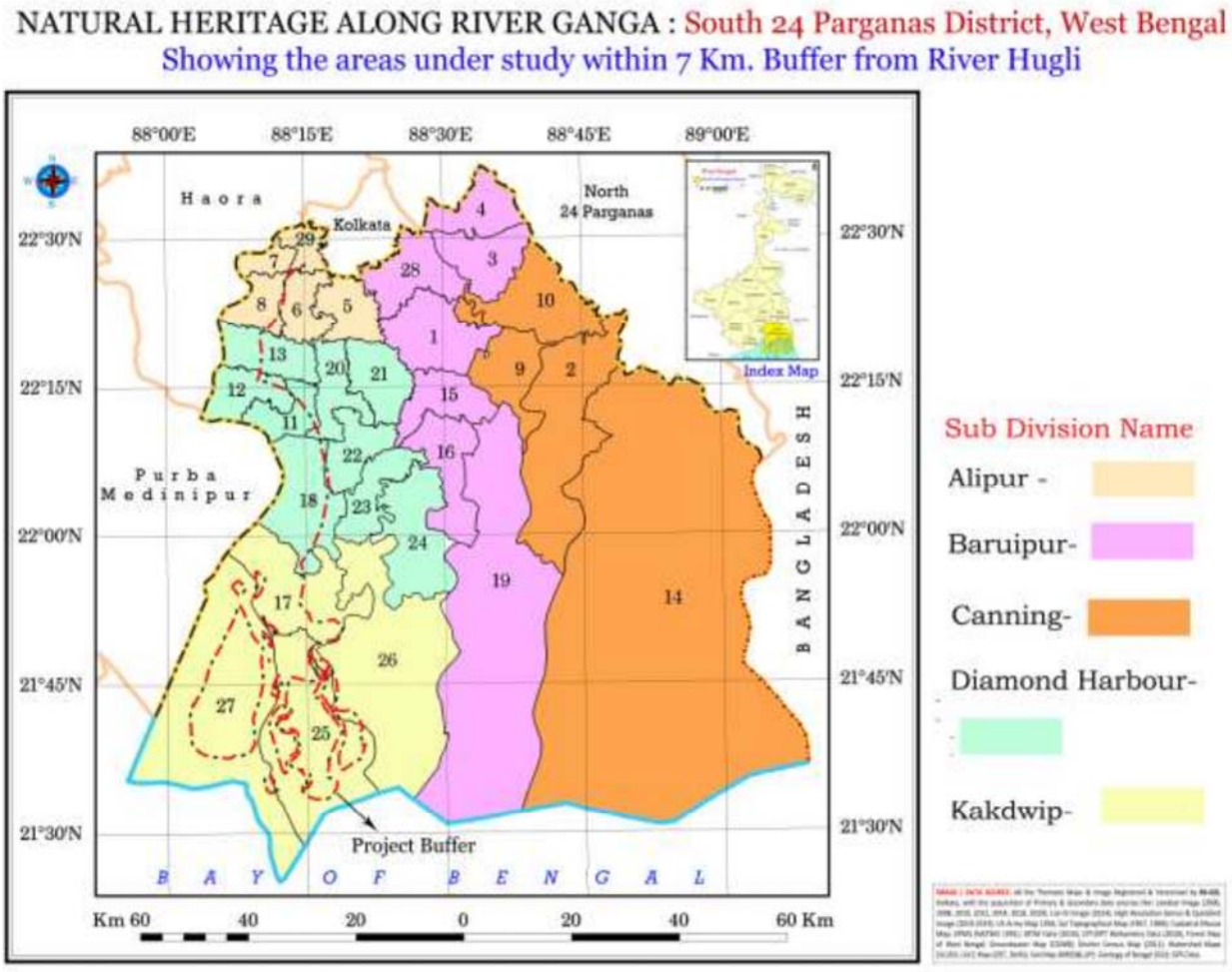
c. **Final Report Submission:** Final Report in form of Soft Copy will be submitted District wise and Hard copy Report will be submitted after completing the all Districts in three phases.



Map 2- West Bengal map showing the study area

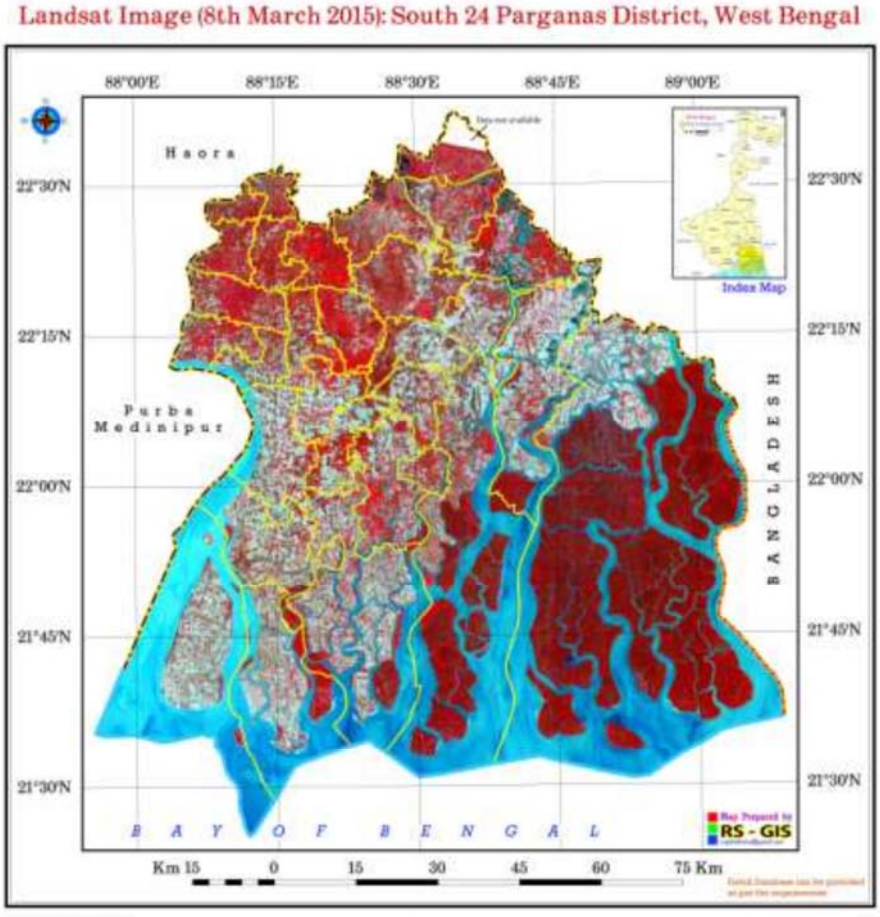
CHAPTER 2 : LOCATIONAL SETTING

2.1. South 24 Parganas with the geographical extension of - 87d55'43.9731"E / 21d35'31.9687"N to 88d57'48.4774"E / 22d36'45.4917"N and area of 9,960 km² is bounded to its due south by the Bay of Bengal, by Bangladesh across the Raimangal and Kalindi rivers to its east, by Kolkata and North 24 Parganas districts to its north-west and north-east respectively and by the districts of Howrah and East Medinipur across the Bhagirathi river to its west. Spreading over an area of 8165 sq. km with a population of 81.5 lakhs in 2011, the district of South 24 Parganas covers almost 9 per cent of the total landmass of the state of West Bengal. The present district of **South 24 Parganas** came into existence on 1st of March, 1986. It then comprised of two sub divisions- Alipore and Diamond Harbour and of 30 blocks. Presently there are five sub divisions (Alipore, Baruipur, Canning, Diamond Harbour and Kakdwip), 29 blocks and 7 Municipalities.



Map 3 – Sub Division Map of S. 24 Parganas

2.2. South 24-Parganas District , mostly belongs to the active deltaic part of the gigantic Ganga Delta formed mainly of enormous thickness of sediments deposited by the two river systems - the Ganga and the Brahmaputra. This lower Ganga Basin is underlain by a thick layer of unconsolidated sediments mainly of the Quaternary age. It exhibits the process of land making in an unfinished state, and presents the last stage in the life of the great river – River Ganga, the stage when it emerges through a region of half land , half water , almost imperceptibly ,into the sea. It has been described as *"a sort of drowned land , broken up by swamps , intersected by a thousand river channels and maritime backwaters , but gradually dotted with clearings and patches of riceland.* (BENG.A.L DISTRICT -GAZETTEERS .24 parganas-1914). The continued deposition of silt producing fertile alluvial soil has made this region one of the most fertile and thickly populated regions in the world. Most inhabitants (up to 94 per cent in the Sundarbans) depend on agriculture. The region is rich in biodiversity, particularly in the aquatic biodiversity and mangroves found in the swampy forests of the Sundarbans. This particular unique biodiversity has been declared as the UNESCO heritage site.



Map 4 – Satellite Image showing South 24 Parganas

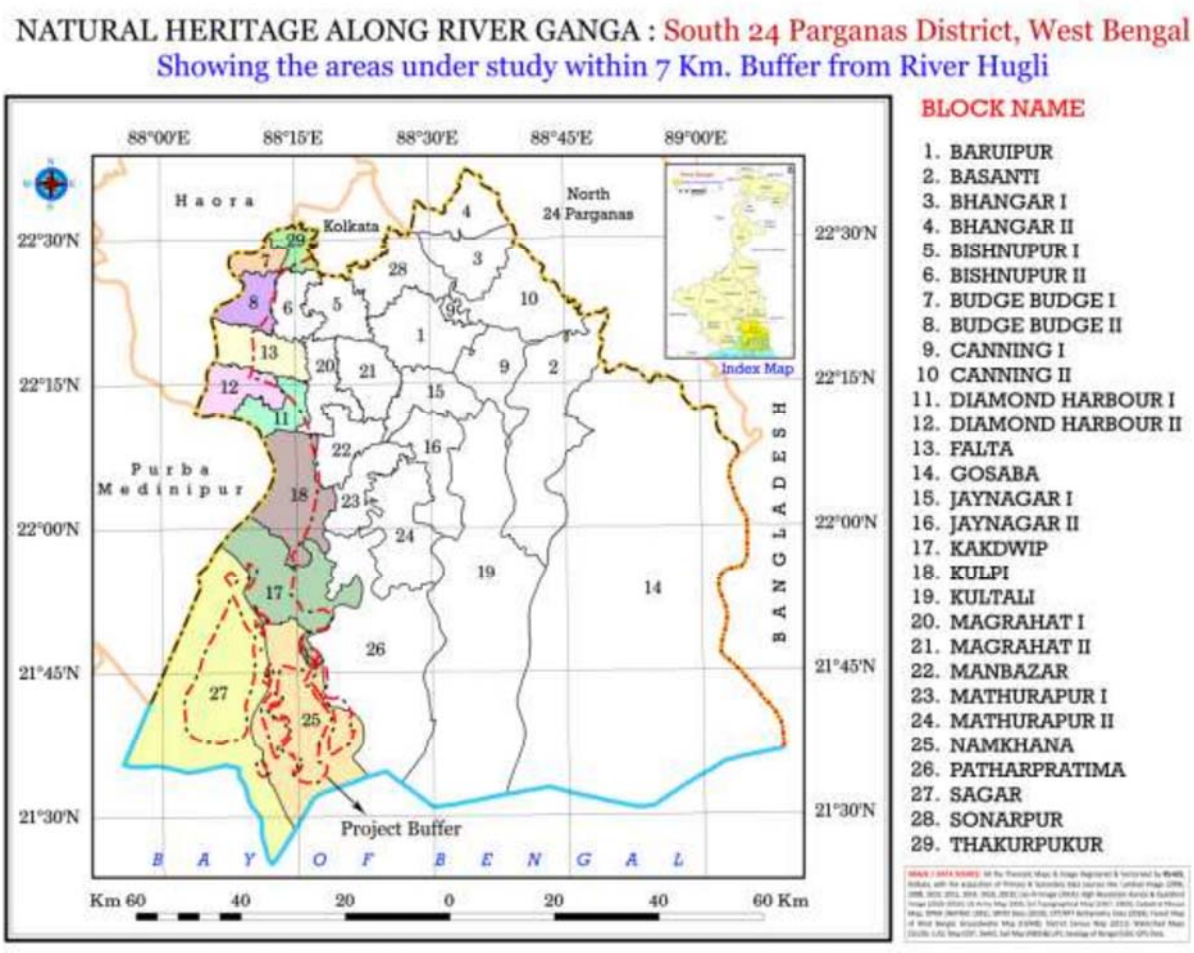
2.3. The nomenclature 24-Parganas has been in vogue since 15 July 1757 when Mir Jafar whom the East India Company had just established as Nawab of Bengal ceded to the Company the rights of 24 mahals. The treaty by which the session is recorded says that "*all the land lying to the south of Calcutta as far as Culpee, shall be under the Zemindari of the English Company and all the officers of this Zemindari shall be under their jurisdiction. The revenue to be paid by it (the company) in the same manner with other Zemindari*". The Parwana notifying effect to the Treaty mentions the name of the 24 units of granted land. The District of 24-Parganas started taking shape under Clause Nos.2, 3 and 9 of the Regualtion of 1793. The respective jurisdictions of the civil and criminal courts for the district and revenue jurisdiction of the District Collector were demarcated by the Regulations. This arrangement remained valid till 1800.

2.4. Study Area: River Ganga in form of its most important distributary , Bhagirathi - Hugli covers about **110 km stretch** bordering this mighty district . For our Study area (7km along the bank of the river) we have 9 Blocks – 1.Sagar- 32930.01 ha 2.Kakdwip- 38774.6 ha 3.Namkhana-40523.25ha 4.Kulpi-24580 ha 5.Falta -13591.67 ha 6.Diamond Harbour- 1 9086.38 ha 7. Diamond Harbour II -11553.51 7.ha Budge Budge II- 8762.56 ha 8.Budge Budge 1 -4791.9 ha 9. Maheshtala - 5562.40 covering about **190157 ha area.**

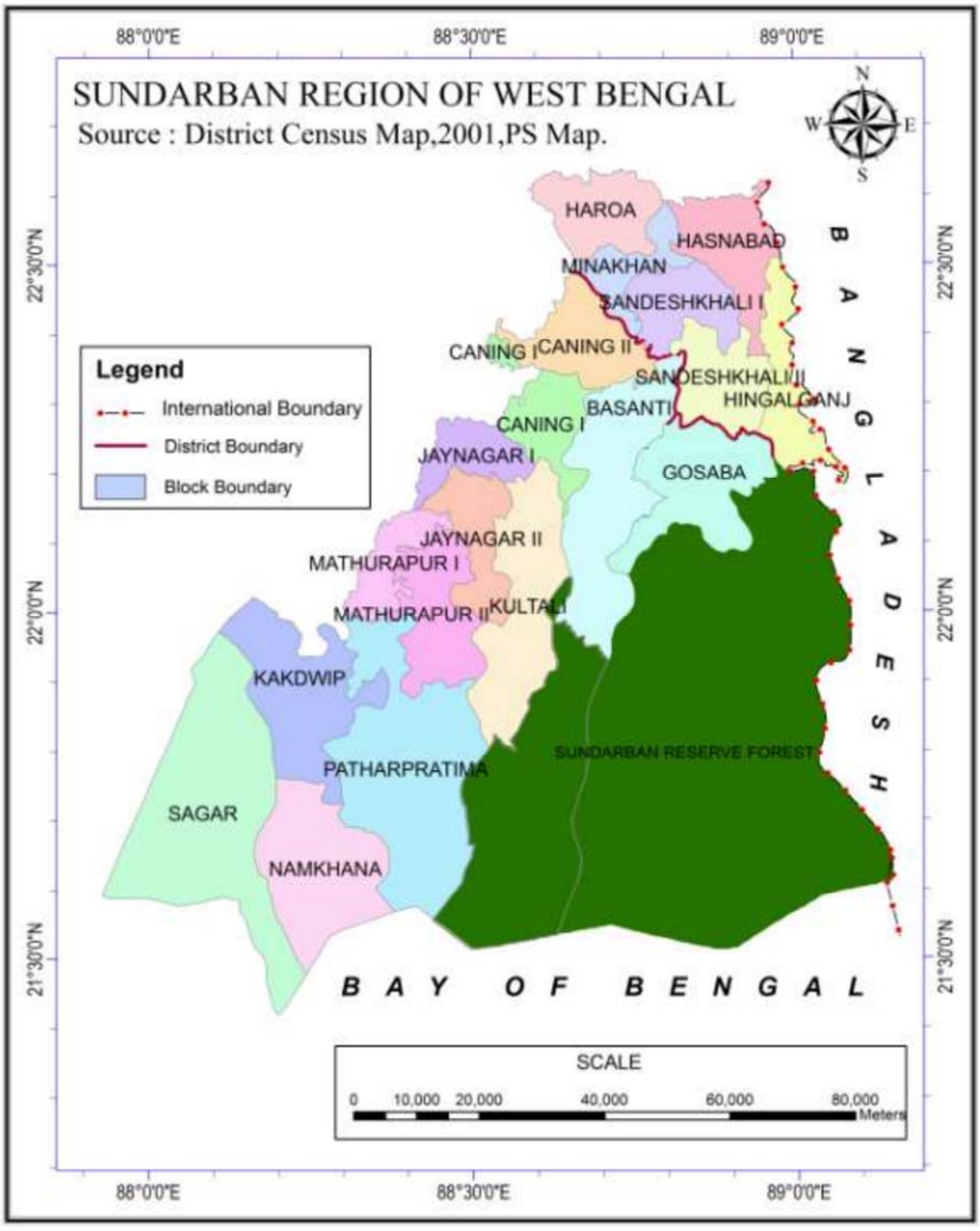
District	**Block**	**Area**
South 24 Parganas	Sagar	32930.01 ha
	Kakdwip	38774.6 ha
	Namkhana	40523.25ha
	Kulpi-	24580 ha
	Falta	13591.67 ha
	Diamond Harbour-1	9086.38 ha
	Diamond Harbour II	11553.51 7.ha
	Budge Budge II-	8762.56 ha
	Budge Budge 1	4791.9 ha
	Maheshtala	5562.40
	Total	**190157 ha**

Plate 1a & 1b – Ganga Sagar , the confluence of Ganga with Bay of Bengal . The Sea and the beach of Gangasagar . South 24 Parganas

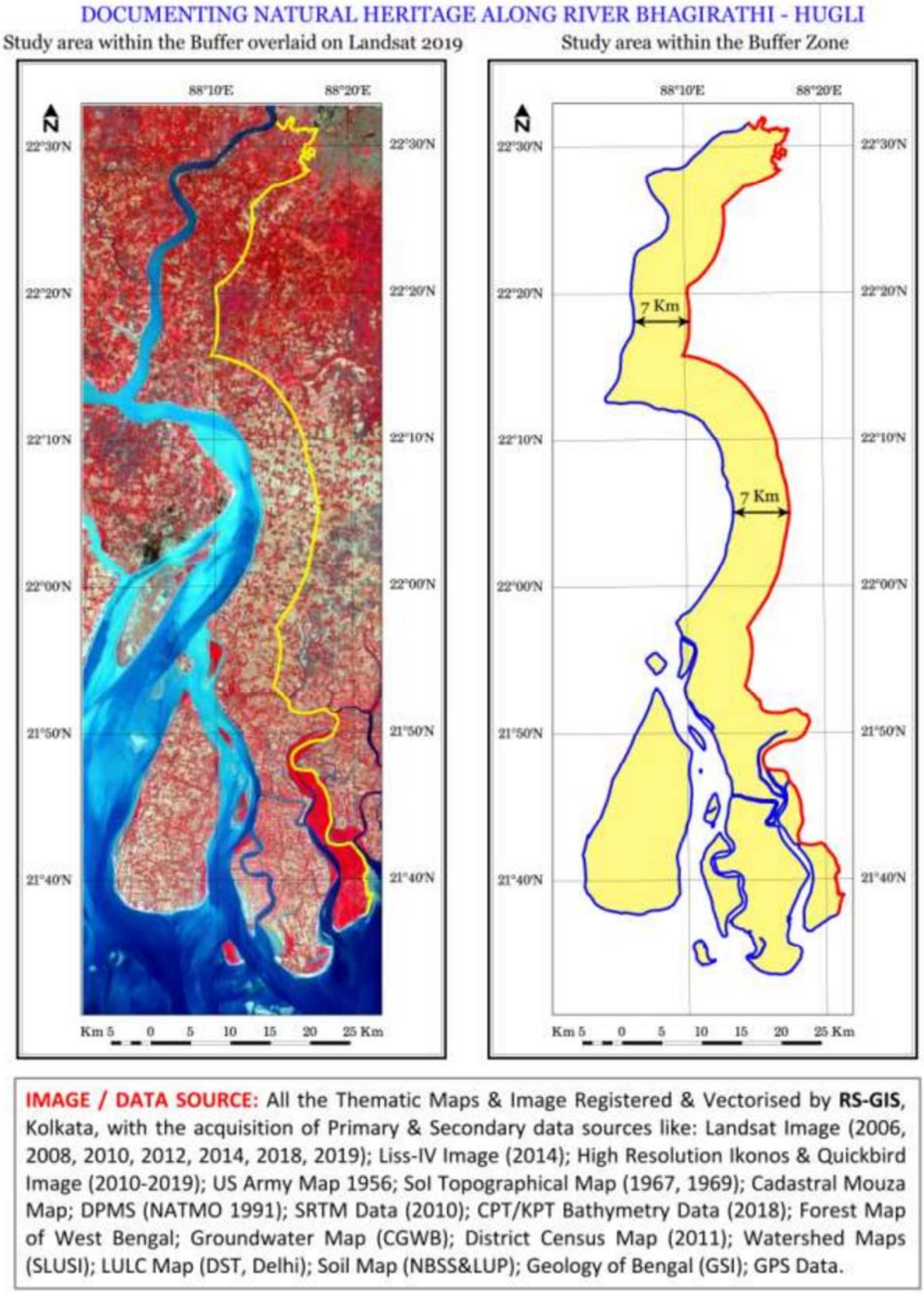
2.5. Amongst these blocks , Sagar Block with Ghoramara Island is completely dethatched from the main land of South 24 Parganas. It is the largest inhabited estuarine island of West Bengal . Kakdwip , Namkhana and Sagar Blocks in our study area also falls under the Sundarbans. Sundarban delta is one of the most mysterious landscapes in the world, which has successively evolved due to sediment accumulation by the great Ganga and Brahmaputra river system. The area is characterized by low-lying islands and a flat topography coupled with macro-tidal activities, powerful surges, and seasonal cyclonic events. All these conditions put together this landscape defenceless to frequent flood and erosion.



Map 5 – The 7 km Buffer Line on South 24 Parganas district



Map 6- Sundarban Region



Map 7- Landsat Image , FCC showing the study area -7km Buffer line

CHAPTER III : PHYSICAL SETTING OF THE STUDY AREA

3.1. **Relief:** South 24-Parganas District, being located in the deltaic plain of the Bengal Basin is apparently a monotonous flat plain with elevations ranging between 3 to 5 m. above mean sea level (m.s.l.). There are also several pockets of raised grounds with elevations of 6 to 8 m. above m.s.l. The region gradually slopes towards the east and southeast. On the basis of micro-variations of terrain, the Study Area falling under the district may be divided into the following morphological units.

a. Hugli Levee
b. Coastal Plain

a. Hugli Levee- This belongs to the left bank natural levee of the Hugli river lying on the western part of Budge Budge, Falta, Diamond Harbour and Kulpi Police Stations. This zone is formed of relatively higher grounds, with the average elevation ranging between 5 to 6 m. above mean sea level.

b. The Coastal Plain : It lies bordering the indented coastline of South 24-Parganas District. This is mainly composed of saline sandy loam or loamy soils. The average elevation of this plain ranges in between 2 to 3 m. above m.s.l. This coastal plain is characterised by the following geomorphic features.

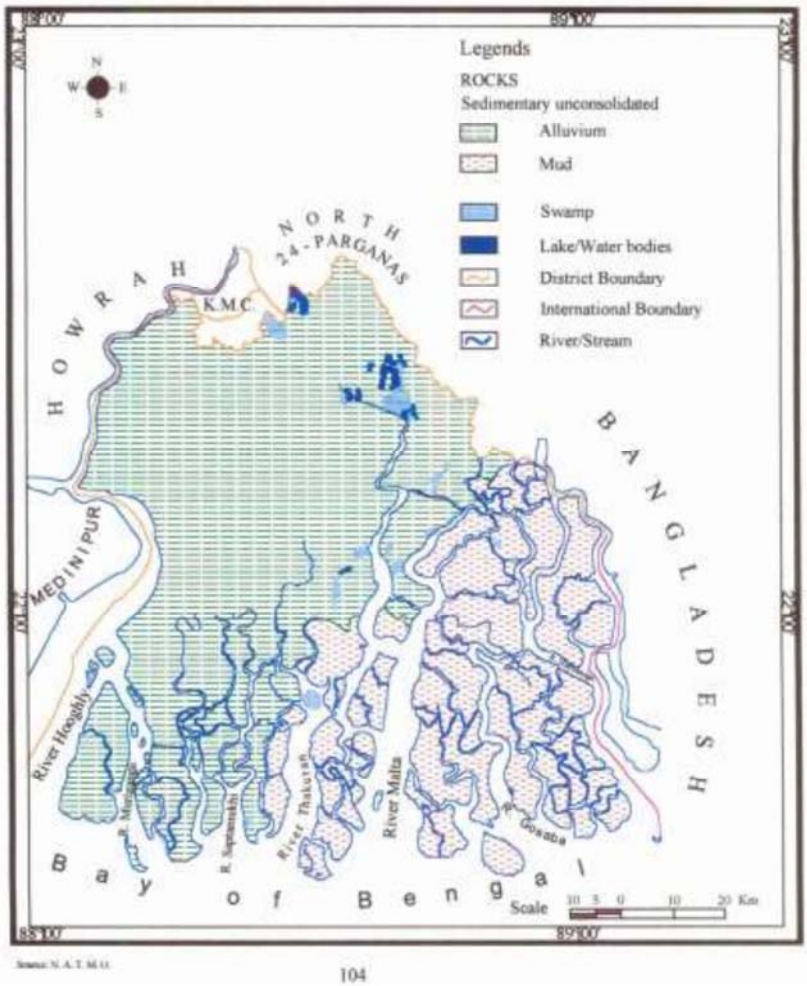
a) Mudflats
b) Mangrove Swamps
c) Sand Banks and Sand Dunes, and
d) Marshes

Extensive **mudflats** backed by mangrove swamps are frequently found in the east and south-eastern parts bordering the estuarine rivers and creeks. Mudflats are also found along Fraserganj coast and the Hugli estuary. **Marshes** are much localised in nature. In the littoral tract of South 24-Parganas, **sand banks** are not very extensive in nature. In the south-western part, particularly at Frazerganj-Bakkhali area, dunes are formed along the coastline in single

alignment. The dunes extend from Frazerganj in the west to the Henry channel in the east for about 600 meters. According to Ray and Bakshi (1980), these dunes are too young to achieve sufficient firmness and stability. These dunes are mostly formed by wind-blown sand, but coastal wave-borne sediments are also partly involved in their formation. The horizontal stratification at the base of dunes emphasizes this phenomenon. The landward sides of the dunes are covered with mangrove vegetation and bushes. Presently casuarina has been planted to protect the sand bank from wave action and ravages of storm surges and cyclones. Patches of isolated beaches are also found in different islands as in Sagar and Jambudwip (Long Island).

3.2. Geology: South 24-Parganas District mostly belongs to the active deltaic part of the gigantic Ganga Delta formed mainly of enormous thickness of sediments deposited by the two river systems - the Ganga and the Brahmaputra. This lower Ganga Basin is underlain by a thick layer of unconsolidated sediments mainly of the Quaternary age. The Quaternary geology of Bengal Basin shows the existence of both Pleistocene and Recent sediments (Morgan and Mclntyer, 1959). Recent sediments are dark in colour and loosely compacted. They are rich in water content and appreciable quantities of organic matters. Pleistocene sediments are flood plain deposits from the earlier Ganga and Brahmaputra rivers. But the major portion of the Delta, of which this District forms a part, is of recent origin. This composite landmass, however, was originated due to a series of geologic and geomorphic processes like upheaval and subsidence coupled with gradual deposition of alluvial silts brought mainly from the Himalayan region by the Ganga and Brahmaputra river system. According to Hooker (1854) and Theobald (1881), the whole of the Lower Bengal Basin was originally an estuary. Historical evidences elucidate the fact that the tidal swamp was once extended upto the Rajmahal Hills (Wadia, 1973). In the late Tertiary period (about 35 million years ago) this estuarine land was gradually filled up by sediments brought down by the Himalayan drainage from the north. It is said that during the early Pleistocene period, shallow marine water conditions prevailed in this part of the Bengal Basin. In the late Pleistocene period, however, the sea receded completely from this area. Then gradually the older sediments started to be overlain by thick strata of river-borne alluvium (Fergusson, 1863). According to another view, the whole deltaic region including the Sundarbans, lying between the Hugli in the west and the Meghnain the east is formed solely by the deposition of debris carried down by the Ganga and Brahmaputra and their numerous tributaries (Oldham,

1893). This view is further substantiated by the fact that there is no trace of marine deposits even much below the ground. However, some estuarine fossils were traced at a depth of about 290 metres while digging a tube-well at Garden Reach under Calcutta Municipality. This part of the Ganga Plain is subjected to tremendous weight of the alluvium brought down by the rivers from the Himalaya, causing sinking of the crust. The whole of the Lower Gangetic Delta as such exists somewhat like a trough land till today (Mitra, 1951).



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Map – 8 : Geomorphology Map of South 24 Parganas.

3.3. Drainage Network : The District is interspersed with innumerable drainage channels including some important **rivers, creeks, cross - channels and several man-made drainage-cum-irrigation canals.** More particularly in the south and south-eastern parts of the District, this drainage network has attained a complex pattern due to the presence of numerous cross channels which ultimately join the major tidal creeks. They have given rise to a large number of islands of various shapes and sizes. These deltaic and tidal streams have their off-take points further upstream either in the Ganga or in the Padma river. To the west of the District, lies the **Bhagirathi - Hugli** which is the most important stream of this system. The lower tidal portion of this stream is called as the **Hugli**, while the upper non-tidal portion is known as the **Bhagirathi**.

In general, these rivers show a **north-south trend**, but some of them maintain south-easterly course as well. Besides variations in local slopes, existence of pockets of depressions or raised grounds also influences the alignments of local drainage system. These channels ultimately find their ways to the Bay of Bengal through any one of the principal estuaries, starting from the **Hugli estuary** forming the western-most boundary of the District to the **Raimangal** in the east. Other principal estuaries are the **Baratala** (a distributary of the Hugli), **the Saptamukhi**, **the Thakuran**, **the Matla** and **the Gosaba**. Amongst these, the Hugli in the extreme west and the Ichamati-Kalindi- Raimangal system receive some fresh water supply from their upstream zones. The supply of fresh water increases during monsoon rain. All other estuaries are beheaded and have become entirely tidal. These estuaries were the lower courses of the Ganga off-shoots in different phases of recent past. Though the upper courses of these rivers are totally disconnected from fresh water supply due to heavy siltation in their feeder channels, their lower courses still remain active owing to regular tidal flow. All these estuaries are inter-connected by intricate network of cross-channels which are generally developed at right angles to the main estuaries. The estuaries in the western part of the District with the exception of the Hugli are smaller in length compared to those in the eastern part. The **Muriganga or Baratala** estuary along Namkhana-Kakdwip area is only 15 Kms. long while the Raimangal stretches via the Kalindi and the Ichamati for about 60 Kms. near Hasnabad-Hingalganj area. The drainage channels of South 24-Parganas may be divided into the following three types

i) Dead Channels : The channels which have lost their connection with one of the main river systems on either side are known as dead channels. Some of these channels are completely choked up with no tide water except during monsoon. Some typical examples are the Giapati in Namkhana-Kakdwip area, Peali, Bidyadhari, Atrabeki, Ghugudanga blind creek etc.

ii) Dying Channels : The channels which are considerably silted up but have regular tidal flow, belong to this category. The upper course of the Saptamukhi estuary, Hatania-Doania cross-channel, Hana cross channel etc. may be cited for example. Some 'khals' connecting two larger ones experience tidal flow from both ends. These are known as **Doaniya khal**, which is one of the unique characteristic of some Sundarban rivers.

iii) Active Channels : All the channels excluding the former two types, which have pronounced tidal action, belong to this type.

iv) Man Made Drainage Canals : Besides these, there are several man-made drainage-cum-irrigation channels, for example **Charial Khal (canal)** draining considerable portion of Budge Budge-Bishnupur Plain, **Keorapukur Khal**, **Surjyapur Khal** and the **Mogra Khal**, all release water in the Hugli river through the main sluice at Diamond Harbour. **Kulpi canal** drains into the Kulpi Plain.

Considerable reduction in the dry weather flow of these rivers results in the silting up of the main river as well as of its tributaries and drainage channels. The lower reaches of these rivers are also being choked up due to lack of sufficient fresh water flow from upland to scour down the silt carried by them. As a result, numerous marshes and water-logged areas are developed in this region owing to drainage blocking. Premature reclamation of land through construction of a series of embankments along the creeks and rivers is also largely responsible for aggravating the problem of siltation in the rivers of this active deltaic zone. Numerous channels, locally known as *khals* draining off the excess rain water from each block of land or islands are also affected- owing to human interference in their natural spill area. This has ultimately disturbed the natural land building process in the active deltaic zone. This has also aggravated the drainage as well as flood problems. Salinity level of water and its neighbouring soils are also raised in this process.

Plate 2 – Muriganga River / Bartala Creek along Kakdwip Jetty Ghat 21°53'4.45"N 88° 9'52.30"E

3.4.CLIMATE

Climate is one of the important natural factor which exerts strong influence in the shaping of landforms, soil formation, drainage characteristics, ground water condition, growth of natural vegetation and related human activities. Therefore various economic activities like agricultural operation, livestock rearing, fishing, location of industries and even the health of the local inhabitants also reveal the influence of climate on human activities.

South 24-Parganas District is characterised by tropical monsoon climate with high humidity and a short dry winter. Due to its location near the sea, the District enjoys modified humid tropical climate with much lower winter spell compared to the inland areas of the country.

The climate of the District is predominantly influenced by the South-West Monsoon. The average annual rainfall of the District exceeds 1500 mm. The monsoon rain, in spite of its erratic nature generally starts during the middle of June, with the inflow of tropical maritime air masses and continues upto the middle of October. January is the coldest month when temperature drops below 12°C. But even in winter, maritime influence makes the local climate quite pleasant. But the summer is very hot and sultry. May is the hottest month when the average temperature shoots up to 35°C. The daily maximum temperature varies from 26°C to 36°C according to season. The air remains highly humid throughout the year due to proximity of sea and presence of numerous tidal rivers and creeks. The highest amount of relative humidity is generally recorded in the month of July-August when the monsoon is at its highest intensites. However, during winter, the relative humidity swings around 75 percent.

Nearly 85 percent of the average annual precipitation occurs during the rainy season i.e. during June to October. During this season the average monthly rainfall exceeds 250 mm. There are regional variations of rainfall. The highest rainfall (over 2,500 mm) is recorded in the south-eastern part of the District. The rainfall gradually decreases to north-west direction where the average annual rainfall is less than 1600 mm. The District also receives some amount af rainfall from the Nor'westers during April-May. These afternoon depressions suddenly develop into violent thunderstorms during late afternoon accompanied by torrential downpours of short duration. This results in fall of temperature, bringing relief to the people. This thundersquall is locally known as 'Kalbaisakhi'. Sometimes these are associated with hail. The wind velocity prevailing over the region fluctuates along with seasonal changes. The winter months show a minimum wind velocity. During pre- and post-monsoon periods, the coastal parts of the District are often seriously affected by cyclonic storms caused by

depressions on the Bay of Bengal. Such cyclones are often associated with tidal bores and storm surges. During such occasions the wind velocity occasionally exceeds 80 Km. per hour or even 160 Km. per hour.

3.5. Soil : Most of the soils derived from the alluvial deposits are azonal with little or no profile development .Clay loam is the predominating type. Clays with or \-\ithout much soils occur in swamps and alluvial lakes. **Alluvial soils** along the coast and especially in the Sunderbans are snow-white efflorescence of sodium chloride. as they are impregnated with this and other salts by tidal estuaries. These soils have been formed from the deposits brought by tidal currents. The cutting of headwater flow through the deltaic branches of the Ganga, has led to the formation of numerous tidal flats. which were subsequently bounded to prevent ingress of seawater. "The parent deposits are either rich in calcium or magnesium consists of half decomposed organic matter. According to the chemical composition of the coastal soils. they are classified as saline, non-saline, alkali and degraded alkali soils. Pure sands forming sand dunes occur mainly along, tile coast. The soils in the Sunderbans can be classified into 5 categories viz ..

(i) Clayey soil Matial/ found in Sagar. Kakdwip, Namkhana, Patharpratima and in parts of Mathurapur Jaynagar, Kultali and Canning P.S. with an approximate area of 1.40,000 hectares. This soil has been further subdivided into three varieties, which are in decreasing order of fertility - Kala Matial!, Ranga Matial and .Jhaira Matial.
(ii) Loamy soil or Doash or Buliara, found in parts of Mathurapur. Kultali and Jaynagar P.S., comprising an area of about 34,000 hectares.
(iii) Sandy loam is found mainly along the Thakuran, Piyali and Kultali rivers.
(iv) Sandy soil predominates along the newly formed islands and is almost incapable of growing vegetation.
(v) Silty soil found in pockets in the reclaimed areas and along the active distributaries of River Padma.

3.6. Ground Water :

In South 24-Parganas district the groundwater occurs in a thick zone of saturation within the thick alluvium of Bengal Basin. Boreholes, drilled in this alluvium in South 24- Parganas, indicate a succession (from top to bottom) of a clay blanket underlain by more porous sediments, even gravels and then again an impervious clay horizon underlain by previous granular sediments. Hydrologically the last bed at the bottom is very important as it contains freshwater of considerable reserve.

In the Study area (southwards through KMC area) groundwater occurs in a confined state as the granular zones are overlain by a blanket of impermeable sticky clay ranging its thickness from 15 to 76 metres.

South of Budge Budge and Bishnupur, the blanket increases in thickness to 100-200 metres in Sundarbans area. The upper sandy gravel bed in **Sundarbans** yields only saline water. The lower horizon yields sweet water usable for irrigation, industrial and domestic purposes. The thickness of the aquifer is also adequate to sustain heavy duty tube wells of 1.5 to 2.0 cusec capacity (District Gazetteers, 1994). It has been recorded by the Geological Survey of India (GSI) that there is slight artesian action from the top most layer (saline) during the rainy season, percepted at Fraserganj sea shore (the Peizometric level being about 1.5 metres above mean sea level). Along the tract of the narrow Adi- Ganga bed (palaeocurse of Ganga) in South 24-Parganas, the major fresh water zone is reached at a shallower depth of 128 metres (rating 4) at Baruipur. This is a local exception from the general trend in the area, as this aquifer depth increases very rapidly moving outward from the old bed (Mukherjee, 1976).

Spatio-temporal Variation in the Depth of Ground Water: The depth of the ground water and its spatio-temporal variation in pre-monsoon and post-monsoon season is revealed by the investigation from a number of bore holes in different C.D. blocks executed by the State Water Investigation Department, Government of West Bengal and Central ground water Board. Analysing depth of the ground water in case of pre-monsoon season it has been observed that, water level varies from 2 metre to 10 metre below the ground level. The water level is nearer the ground level in the lower part of the deltaic plain than its upper part. The same is true in case of post monsoon ground water level. Ground water exploitation is effected by salinity hazard in all over the district.

3.7. Natural Vegetation:

The vegetation of the South 24-Parganas may be classified by the type of delta (moribund, mature and active), type of soil and its water content and other biotic factors. The broad classification is:

I. Vegetation on agricultural fields of the moribund and mature deltaic areas;

2. Vegetation on freshwater pools, pools and rivers; and

3. Vegetation on the active delta.

In the mature and moribund delta cultivated crops have replaced the natural cover. The cultivated crops consist of vegetables of various kinds of cereals. Pulses, fibre plants, oil-seed crops and other food accessories. Rice is the most important cereals. Various types of weeds occur on the paddy fields. Many algae and angiosperms are also common in the low-lying areas. Around settlements and along roads many indigenous as well as exotic varieties of fruit trees bamboo grove flowering garden plants and low scrub strand out prominently against the cultivated stretches. In the freshwater pools, ponds and rivers various *pteridophytes* and *angiosperms* occur in abundance. The most distinctive unit of vegetation occurs in the active delta popularly known as the **Sundarbans**. In our study area we find it in Sagar Block and Namkhana Block.

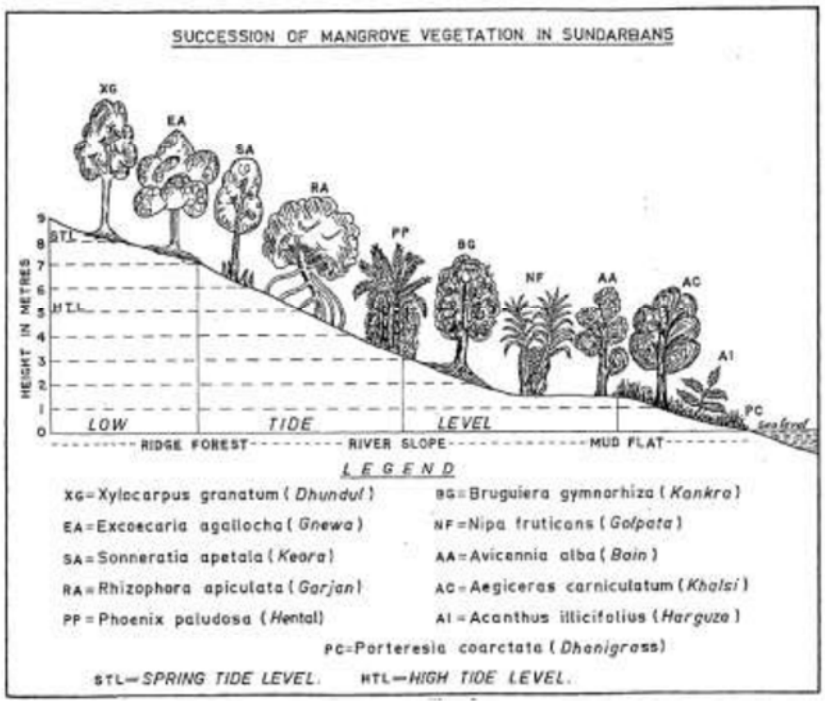
The stretches of low-lying land under rice cultivation afford a foothold for numerous marsh species, like *Sphenoclea, Hydrolea, Ammania. Enhydra, Wedeha, Sesbania* while the numerous ponds and ditches arc tilled with submerged and floating water plants, like *Utricularia, Pislia. Hydrila. Lagarosiphos*. Remarkable among these for its rarity and interesting on account of its distribution in Europe on the one hand and Australia on the other, is the floating *Droserad Aldrovanda*. The edges of sluggish creaks are lined with large sedges and bulrushes, the banks of rivers have a hedge like scrub jungle of *Dalbergia* and *Caesalpina, with climbing lpomoeas*. *Argyreias and Menisperms* and a few trees like, *Pongamia glabra*, *Barringtonia acutanqula* and *Thespesia populnea*. The sides of embankments and village sites, where not occupied by habitations, are densely covered with village shrubberies of semi-spontaneous species like *Odina Zizyhus*, *Acacia, Glycosmis* and *Trema* often interspersed with clumps of planted bamboos and groves of *Areca, Moringa. Mangifera and Anona*. Waysides and waste places are filled with grasses and weeds usually of little intrinsic interest but often striking because of their distribution. A very large proportion or the species or this class to be met within the district has been inadvertently introduced by human agency; besides weeds that are indigenous in other parts of India, these

Plate 3 – Hogla Grass, *Typha elephantiana of family Typhaceae*, found all along the lower reaches of Hugli River , associated swamps and canal . Location –In a swamp near Batanagar , Budge Budge 22°30'53.99"N 88°12'56.91"E, Plate 4 – Location - Near Pujali , Budge Budge , 22°28'20.95"N 88° 8'16.08"E

include European or African species like *Senebrera pinnatifide* and *Xanthium Specidsum* and especially American species like *Ageratum conyzoids* , *Scoparia duties*, *Wissadula rositrata* , *Evolvulus nummulasifolius* , *Pepromia pellucid*, *Malachra Capitata* , *Herpestris Chamoedryoides*, *Croton sparsiflrus* and many others , which not only hold their own with, but spread more plentifully than, similar weeds of truly Indian origin.

The active delta, still growing southwards, is a system of innumerable tidal rivers, canals and creeks; sand dunes, saline soils, swamps and marshes. Much of it is terra incognita, due to the inaccessible 'mangrove swamps'.(the humid marshy tropical forests. called Sundarbans), which stretch for about 150 km. from west to east and 50 km. from north to south through a network of numerous tidal islands.

A newly formed island in this forest belt is first colonized by dhani grass (*leersia hexandra*) and Baruna grass (*Sesuvium portulacuslram*) which are followed by tree species like Baen Keora and khalsi (*Aegiceras ma*). After the soil has stabilized by the regular deposition of silt from tide and river water the next species to settle are Goran (*Ceriops roxburghiana*) Gengwa (*Excaecaria agallocha*), clumps of Hental (*Phoenix paludosa*) and Golpatta (*Nipa fruiticans*). When the level is further raised so that the islands arc flooded only occasionally by salt water the Kankra (*Bruguiem gymnorhiza*) , Sundari (*Heritiera minor*) and Passur (*Carapa moluceensia*) make their appearance and soon occupy the greater portion of land. Along the creeks the species that always come up are Garjan (*Rhizophora conjugata*) and Dhundul (('ompa ahovota). The red mangrove shows an ability not only to survive and colonize an environment impossible for most other trees, but even too built up new land. A tangle of roots and trunks that seems at first indecipherable a mangrove



forest on closer examination sorts itself out into a meaningful structure that actually traps flotsam of all kinds in shallow waters where it grows , gradually forming solid ground from the decaying mass. The origin of a mangrove forest can be a single seedling which germinates while the fruit still remains attached to the tree and before separating from the parent tree develops a long radicle (1 to 2 feet long and 0.5 inch in diameter at the tip). This radicle perforates the apex of the fruit and elongates while the fruit still remains on the tree. When fully developed this elongated club-shaped radicle separates from the tree and falls perpendicularly down into the mud below by its own weight and fixes itself there by its pointed and heavy end. Once rooted, the mangrove seedlings have been observed to grow an inch an hour and bear fruit when four feet high . The black mangrove develops special roots are provided with a scabrous bark full of groups of airholes, called lenticels through instead of going down and spreading under the soil, rise from the soil with their tips out into the air.

No.	Vernacular name	Scientific name
1.	Sada Bain	*Avicennia alba*
2.	Piara Bain	*Avicennia marina*
3.	Kalo Bain	*Avicennia officinalis*
4.	Dhani Ghass	*Porteresia coarctata*

These aerial roots are provided with a scabrous bark full of groups of air holes called lenticels , through which knticels through which the roots are aerated. Such roots arc therefore known as breathing roots . All mangroves protect the shore from erosion and aid in the accumulation of deposits of peat and mud. Mangroves are usually heavily populated beneath by snails, crabs and other marine species. According to latest classification, the South 24-Parganas has two types of forests. Salt Water or Heritiera Forest and Low Mangrove. Both have dense impenetrable undergrowth. The upper storey of the former is comprised mainly of Gengwa, Passur, Dhundul and Sundari (Black mangrove). The latter group has composition similar to the first but the height, of the crop is much lower. **Golpatta** is almost absent while red mangroves (without breathing roots) arc more common. It was estimated that out of 900 sq. miles (2331 sq.km) of forested area about 801 sq.miles (2074.59sq.km) are under Salt Water Heritiera type and 99 sq.miles (256.41 sq.km) are under Low Mangrove. Out of different species available in the Sundarbans the only species that have potential to grow to a size are Passur, Keora, Gengwa and Sundari. Of these only Passur grows to a girth of 6 ft. (1.828 m.) and is used for different constructional purposes. The others limited to a girth of less than 3 ft. (0. 914 m.) are normally used as posts or as firewood. Some of the mangrove trees are good for tanning materials and may also be used for pulp making.

Amount of Mangrove Plantation in our Study Area –

Location (Block)	Area in sq.km
Sagar Block	2.66 sq. km.
Kakdweep	87.80sq.km
Namkhana	250.03sq.km

Vegetations recorded in the estuarine mouth area of Hugli River is mostly Mangroves and Grass. Because of high tidal influence Bain and Dhani Grass are most abundantly found.

Principle Species of Natural Vegetation Found In the Hugli Estuarine Islands
(a) Tidal Vegetation (Mangroves) Table -1

Sl. No.	Species	Plant type	Habitat	Occurrence	Uses	Local name
1	*Aeluropus Lagopoides*	Grass	Sand-dominated tidal flat	-	Fodder, extensively consumed	Nona Durba
2	*Cynodon Dactylon*	Grass	Sand-dominated tidal flat	-	Fodder	
3	*Porteresia Coarctata*	Grass	Open mud flat: lower part	-	Fodder, extensively consumed	Dhani Ghas
4	*Spinifex Litorina*	Grass	Intertidal sand: lower part	-	Fodder	
5	*Salicornia Brachiata*	Herb Open	Open mud flat: upper part	Common	Fodder	Brahmi Shak
6	*Suaeda Maritima*	Herb	Open mud flat: upper part	Common	Fodder	Giriya Shak
7	*Acanthus Ilicifolius,*	Shrub	Mud flat/ creek bank: lower part	Common	Fuel medicine	Harkach Kanta
8	*Phoenix Paludosa*	Shrub	Mud flat: upper part	Localised	Housing/sie n netting	Hental
9	*Avicennia sp.*	Tree	Mud flat/ creek bank: lower and upper parts	Common	Timber, fuel	Bani
10	*Bruguiera sp*	Tree	No natural occurrence:	. being reintroduced	Timber, fuel, tannin	_ Kakra
11	*Ceriops sp.*	Tree	Creek bank: upper part	Rare	Sien netting, timber, fuel	Garan
12	*Excoecaria Agallocha*	Tree	Mud flat/ creek bank: upper part	Common	Timber, fuel, uses in newsprint, packaging and match industry	Genwa
13	*Heritiera Fomes*	Tree	No natural	being	timber	Sundari

			occurrence:	reintroduced _		
14	*Kandelia*	Tree	Upper mud flat	Localised	candel -	Pashura
15	*Rhizophora sp.*	Tree	Creek bank: upper part	Rare	Timber, fuel, tannin	Bora
16	*Sonneratia sp.*	Tree	No natural occurrence	: being reintroduced	Timber, fuel	Keora

(b) Supratidal Vegetation (Non-Mangroves)

Sl. No.	Species	Plant type	Habitat	Occurrence	Uses	Local name
1	*Ipomoea Pescarpae*	Herb	Ubiquitous	Common	Fuel, fodder	Changal kurni lata
2	*Launaea Sarmentosa*	Herb	Dune top (in combination with l.pescarpae)	Common	-	-
3	*Sesuvium Portulacastru m*	Herb	Sand flat	Common	Human consum ption	Gadaba ni
4	*Opuntia Dillenii*	Shrub	Dune/back-dune area	Localised -	-	Mansa kanta
5	*Tamarix Gallica*	Shrub	Dune-island interior transitional zone	Localised -	-	Banjhau
6	*Calotropis Gigantea*	Sedge	Dune slack and back-dune	Rare	Fuel, fodder, medicin al uses	Akanda
7	*Cyperus Exaltatus*	Sedge	Dune slack and sand flat	Localised	Fodder, fuel, thatch	Mutha ghas
8	*Lpomoea Aquatica*	Sedge	Dune-island interior transitional zone	Localised -	-	Kalmi
9	*Pandanus Faccicularis*	Sedge	Dune slack and back-dune	Rare -	-	Keya

Plate 5– Dhani Grass , *Porteresia coarctata* found in the mud flat region of Sagar Island 21°48'30.88"N 88° 9'59.97"E , Plate 6 – Mahisani Island , Namkhana Block 21°38'14.50"N 88°13'35.40"E

Plate 7 - Bain or Indian mangrove (*Avicennia officinalis*, family: *Verbenaceae*) is a medium-sized evergreen tree of Mangrove forest with breathing roots. It can get a height of 7-25 m. Young trees are usually bushy-natured and get a large crown. Location- Beguakhali , Sagar Island.

Plate 8- Sesuvium Portulacastrum in the sand flat of Dhoblat , Sagar Island

Plate 9 & 10 – Mangroves along the Chemaguri Creek, Sagar Island , 21°40'59.17"N 88° 9'0.57"E

Plate 11 – Mangroves in Henry Island , Namkhana , Plate 12 – Mangroves in Beguakhali , Sagar Island

3.8. Fauna of the Study area

In terms of zoo geography South 24 Parganas is unique among all other districts of West Bengal as well as India. Here in this district three great bio-cycles of ocean, fresh water and land come into contact. The succession from ocean to land and to fresh water through estuaries is the most fascinating field for ecologists. The gradient from salt water to brackish water to entirely fresh water fluctuates back and forth with the tides. Species of marine organisms extend towards fresh water as far as permitted by their tolerance of reduced salinity: and the species of fresh water are just the reverse way about. Thus the intermediate zone of brackish water under the salt marshes is one of the most fertile areas of the world. With uniform hot wet climate throughout the year, cold blooded animals have several generations a year; birds breed during the summer. Many insects complete their life cycle in three or four weeks and may have several generations during wet period. On the other hand, high uniform temperatures are depressing for the metabolism and activities of the warm blooded animals, and the pace of their activities is comparatively slow. Cold blooded animals of West Bengal, particularly reptiles and arthropods, reach their largest adult size in the South 24 Parganas. Invertebrate animals occur in the greatest variety and number on the forest floor. The entire district has been classified under Oriental zoogeographical region. But many elements of Indo- Chinese, Ethiopian and Palaearctic are also found. Pollution due to industrial wastes and also change in salinity in the estuarine parts caused many changes in the biota. Such disturbances have wiped out some of the old species, such as the lesser One-horned Rhinoceros, which were once common in this area. Pollution due to the industrial wastes and also change in salinity in the estuarine parts caused many changes in the biota. As a rule the food chain has got a setback and species, depending on particular were forced to change their foraging areas.

Based on the survey done by - (Roy Chowdhury, 2005:64-115; Das, 2006: 113-240 O'Malley 1914, reprinted 1998: 22-29; Hunter, 1876, reprinted 1998: 20; Bijaykrishna Chakrabarty, 2007:111) there are 1586 species different types of marine invertebrates, fish, turtles, tortoises, terrapins, lizards and crocodile, snake, amazing variety of birds, wild and other animals were remarkable. Based on our survey we have documented few of them . They are -

a.Marine Invertebrate: Sea fir (*Obelia species*), seaanemone, hermit crab (Diogenus species), nudibranch (*nudibranchs*), jellyfish (*Acromitus sp.*), telescope shell (*Telecopium telescopium*), feathered starfish (*Astropecten euryacanthus*), mantis shrimp (*Squilla nepa*), ghost crab (*Ocypoda sp.*), sweeming crab (*Matuta victor*), yellow fiddler crab (*Uca triangularis*), red fiddler crab (*Uca rosea*), etc.

Plate 13– Red Crabs, Henry Island

Plate 14- Star Fish , Gangasagar Beach , Plate 15,16,17,18-Fiddler Crabs , Chemaguri Khal , Sagar Island

b. Fish: The numerous fin fishes in estuaries of Sundarbans include a variety of 120 species. There are abundant occurrences of tiger shark, dog shark and 22 species of prawn in the Sundarbans river waters. Some of these are as follows Air, bamli, ban (*M. talanboroider*), ban (*Pisodonephis hijala*), ban (*Mastocembelus armetus*), tola-ban (*Muraenesox cinereus*), bele (*Sillago Sihama*), bhangan (*M lade*), bhetki (*hates calcarifer*), kai-bhola (*Pomadasys maculatus*), kai-bhola (*Epinephelus diacanthey*), boal, bowl, chanda (*Pama pama*), chapila/ganges shad (*Gudusia chapra*), chapra, chela, chitra, corsula/grey mullet (*Liza corsula*), mocha chingri or cyay-fish, gagra, goichi (*Macrognathus aculeatus*), gule, gutia, hilsa shad (*Hilsa ilisha*), chandans-hilsa/toli shad (*H. toll*), kalibaus (*Labeo calbasu*), kan magur (*Plotosus cams*), katla (*Catla buchanani*), full-beak kantla (*Strongylura annulatus*), half-beak kantla (*Hemirhamphus sp*.), kakila, katamed, kendo, khaira (*Sardinella sp.),* khanda (*Chirocentus dorab*), koi (*Anabas scandens*), lata, lotia/bombay duck (*Harpodon nehereus*), magur (*Clarius magur*), mirgal (*Cirrhina mrigala*), morayeel (*gymnothoraxfavagineus*), mourala, flat head mullet (*Mugil cephalus*), parse/gold spot mullet (*M. parsia*), pankal (*M.pancalus*), payratali, phansa (*S. phasa*), phansa (*Coilia dussumiera*), phansa (*C. ramkarati*), pungus (*Pangasiuspangasius*), ray fish/Sting ray (*Dasyatissp.),* white spotted shovel nosed ray (*Rhynchobatus djiddensis*), poa, puti, prawns, pyra chanda (*Scatophagus argus*), white promfret (*Chondropites chinensis*), grey promfret

Plate 19– Ray Fish / Shankar Fish amongst the fish catch in Gangasagar . 21°38'7.58"N 88° 4'22.53"E

(*Stromateus argentus*), rekha, ribbon fish (*Trichiurus sp*.), rohi (*Labeo rohita*), rucha selanda, bamboo shark (*Chiloscyllium sp*.), dog shark (*Scoliodon sp.),* hammer head shark (*Sphyma sp*.), tiger/zebra shark (Stegostoma sp.), whale shark (*Rhinchodon sp*.), pointed saw fish (*Pristis cuspidates*), small tooth saw fish (*Pristis Microdon*), singi (*Saccobranchusfossilis*), shol, tapse/paradise thread fin (*Polynemus padiseus*), tengra, tepa/toad fish (*Tetrodon cutcutia*), tonge fish/tongue sole (*Cynoglossus sp*.), tul, vangar, vola, etc.Among the reptiles following types of turtles, tortoises, terrapins; lizards, crocodiles; and snakes are found in this region

c.Turtle, Tortoise, Terrapin: Green turtle {Chelonia mydas), olive ridley turtle {Lepidochelys olivacea), river terrapin (*Batagur baska*), green turtle (*Chelonia mydas*), narrow headed soft shell turtle (*Chitra indica*), gosap and green viper, painted roofed turtle (*Kachuga kachuga*), spotted pond turtle (*Geoclemois hamiltonii*), etc.

Plate 20- Mudskippers , Mahisani Island

Plate 21– Fresh catch of tiger prawns & other fish from Mahisani Island

Plate 22 – Assorted fish catch in Bokkhali Beach, Namkhana Block .

Plate – Fresh fish catch in the Beguakhali Creek , Sagar Island

d. Reptiles - Water monitor, marsh crocodiles, estuarine crocodile (*Crocodylus prosus*), chameleon (*Chamaeleon zeylanicus*), tokay (*Gekko gecko*), house gecko (*Hemidactylusflaviviridis*), grey house gecko (*Hemidactylus brookii*), garden lizard (*iCalotes versicolor*) etc..

King cobra (*Ophiophagus hannah*), Indian cobra (*Naja naja*), manacled cobra, russels viper (Daboia russelli), banded crait (Bungariis fasciatus), wolf snake (.*Lycodon aulicus*), common checkered keelback (*Xenochrophis piscator*), common smooth water snake (*Enhydris enhydris*), glossoi marsh snake (*Acrochordus granulatus*), sea-snake (*hydrophis nigrocinctus*), Indian python (*Python Molurus*), sand boa (*Eryx conicus*), rat snake (*Ptyas mucosa*), greenwhip snake (*Ahaetulla nasuta*), ornamental snake (*Chrysopelea omata*) etc..

Plate 24 – Monitor Lizard , near MuriGanga Creek , Sagar Island

Plate 25 – Black Cobra , in the creeks of Sundarbans .

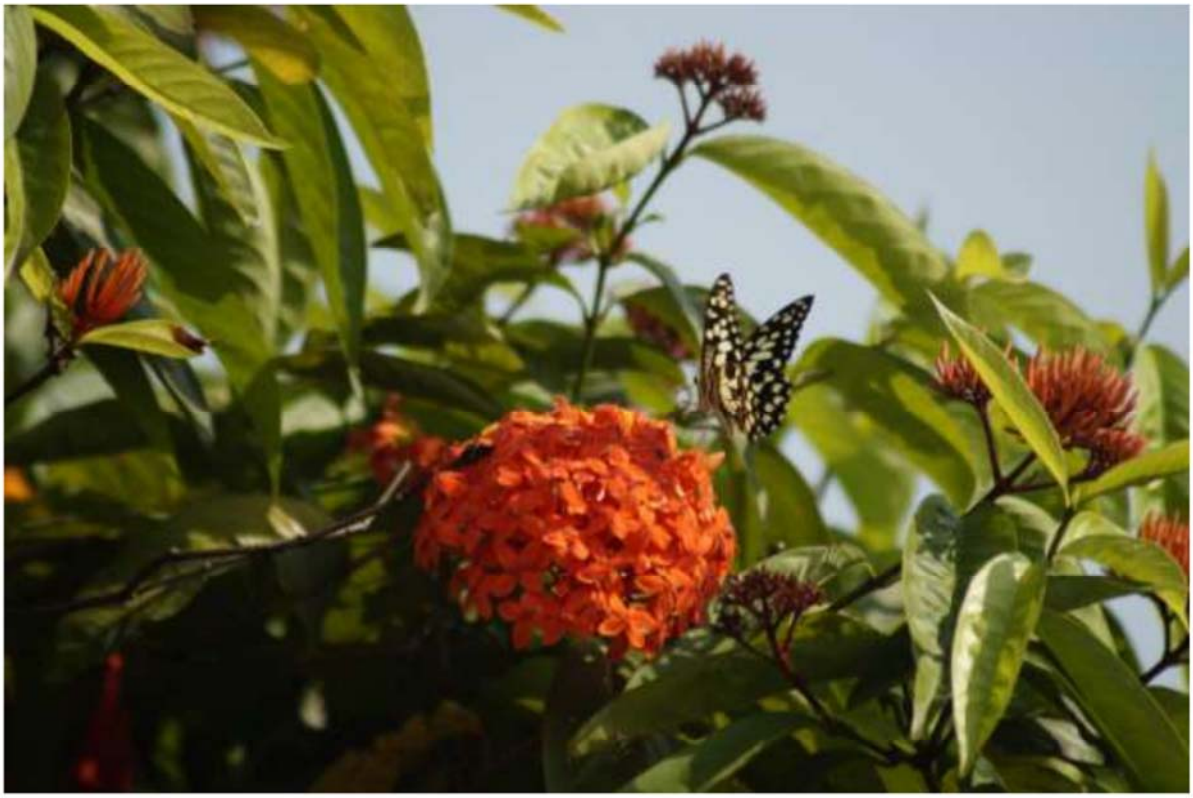


Plate 26 – Butterflies in the Bakkhali Beach area.

e. Birds – Our Study area hosts 2 major hotspots for birds - Sagar and Henry Island. The location and topography of both the areas makes them an excellent bird-watching site. Many species have been recorded here and include good birds like Amur Falcon, Terek and Curlew Sandpipers, Dunlin, Sanderling and Great-crested Terns along with common species of Gulls and Terns.

As we have surveyed , we recorded the following species in the different zones.

A. Budge-Budge – Diamond Harbour

Sl No	**Name of the species**	**Scientific name**	**Present status**
1	White Breasted Kingfisher	*Halcyon smyrnensis*	Less concerned
2	Pied Kingfisher	*Ceryle rudis*	Less concerned
3	Coppersmith Barbets ,	*Megalaima haemacephala*	Less concerned
4	Green throat Barbets	*Bucco franklinii*	Less concerned
5	Small minivet	*Pericrocotus cinnamomeus*	Rare sightings
6	Common kingfisher	*Alcedo atthis*	Less concerned
7	Spotted dove	*Spilopelia chinensis*	Less concerned
8	Spotted Owl	*Strix occidentalis*	Rare sightings
9	Orange-breasted green pigeon	*Treron bicinctus*	Rare sightings
10	Egrets	*Ardeidae*	Less concerned
11	Pond Heron	*Ardeola*	Less concerned
12	Common Sterlings	*Sturnidae*	Rare sightings
13	Rose Ring Parrot	*Psittacula krameri*	Less concerned
14	Black Hooded Oriole	*Oriolus xanthornus*	Less concerned
15	Flame Back Woodpecker	*Dinopium benghalense*	Less concerned
16.	Black Coucal	*Centropus grillii*	Less concerned
17.	Black Kite	*Milvus migrans*	Less concerned
18	Bronze Winged Jacana	*Metopidius indicus*	Less concerned
19	Water Hen	*Amaurornis phoenicurus*	Less concerned
20	Rufous Treepie	*Dendrocitta vagabunda*	Less concerned

B. Kakdwip-Sagar Island

Sl No	Name of the species	Scientific name	Present status
1	Gulls	*Larus*	Only in Muri Ganga , Bakkhali area
2	Whiskerd Terns	*Chlidonias hybrida*	Only in Muri Ganga , Bakkhali area
3	Little Terns	*Sternula albifrons*	Only in Muri Ganga , Bakkhali area

4	Sand Piper	*Sandpiper/Scientific name Scolopacidae*	Only in Muri Ganga , Bakkhali area
5	White BreastedKingfisher	*Halcyon smyrnensis*	Less concerned
6	Common Kingfisher	*Alcedo atthis*	Less concerned
7	Pied Kingfisher	*Ceryle rudis*	Less concerned
8	Vultures	*Cathartes aura*	Rare
9	Spotted Owl	*Strix occidentalis*	Rare
10	Jungle Fowls	*Gallus*	Less concerned
11	Little Egrets	*Egretta garzetta*	Less concerned
12	Pond Heron	*Ardeola*	Less concerned
13	Black hooded Oriole	*Oriolus xanthornus*	Less concerned
14	Copper smith Barbets	*Megalaima haemacephala*	Less concerned
15	White Bellied Sea Eagle	*Haliaeetus leucogaster*	Very Rare
16	Red Wattled Lapwing	*Vanellus indicus*	Less concerned
17	Red Muniah	*Amandava amandava*	Rare
18	Scaly Breasted Muniah	*Lonchura punctulata*	Less concerned
19	Stone Chats	*Saxicola*	Less concerned
20	Verditer Flycatchers	*Eumyias thalassinus*	Rare
21	Swallow	*Hirundinidae*	Less concerned
22	Brahminey Kite	*Haliastur indus*	Rare

C. Namkhana - Bakkhali –Henry Island-Moushuni Island

Sl No	Name of the species	Scientific name	Present status
1	Golden Plover	*Pluvialis fulva*	Migratory , Henry Island
2	Kentish Plover	*Charadrius alexandrinus*	Migratory , Henry Island
3	Little Terns	*Sternula albifrons*	Migratory , Henry Island
4	Sand Piper	*Scolopacidae*	Less concerned
5	White BreastedKingfisher	*Halcyon smyrnensis*	Less concerned
6	Common Kingfisher	*Alcedo atthis*	Less concerned
7	Pied Kingfisher	*Ceryle rudis*	Less concerned
8	Ruddy Turnstones	*Arenaria interpres*	Migratory , Henry Island
9	Spotted Owl	*Strix occidentalis*	
10	Jungle Fowls	*Gallus*	Less concerned
11	Egrets	*Egretta garzetta*	Less concerned
12	Pond Heron	*Ardeola*	Less concerned
13	Black hooded Oriole	*Oriolus xanthornus*	Less concerned
14	Barbets	*Megalaima haemacephala*	Less concerned
15	White Bellied Sea Eagle	*Haliaeetus leucogaster*	Rare
16	Red Wattled Lapwing	*Vanellus indicus*	Less concerned

17	Red Muniah	*Amandava amandava*	Rare
18	Scaly Breasted Muniah	*Lonchura punctulata*	Less concerned
19	Curlew	*Calidris ferruginea*	Migratory , Henry Island
20	Veriditer Flycatchers	*Eumyias thalassinus*	Less concerned
21	Sand Plovers,	*Charadrius mongolus*	Migratory , Henry Island
22	Hoopoe	*Upupidae*	Less concerned
23	Green Bee Eaters	*Merops orientalis*	Less concerned
24	Indian Rollers	*Coracias benghalensis*	Less concerned
25	Red Wattled Lapwings	*Vanellus indicus*	Less concerned
26	Snipes	*Gallinago gallinago*	Migratory , Henry Island
27	Pranticoles	*Glareolinae*	Migratory , Henry Island
28	White Throated Fantail	*Rhipidura albicollis*	Rare
29	Citrine Wagtails	*Motacilla citreola*	Less concerned
30	Cuckoo	*Cuculidae*	Less concerned

Plate 27 - Sand Plovers, *Charadrius mongolus,* Migratory species in Henry Island.

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Plate 28 - Little tern, Henry Island

Plate 29 – Pond Heron , Budge Budge Outskirts

Plate 30– Gulls , Muri Ganga , In between Kakdwip and Sagar island. Plate 31 – Egret with a catch in paddy field of Namkhana

Plate 32 – Caspean Tern , Migratory Birds , Henry's Island , Namkhana

Plate 33 – Asian Koyel , shot during survey , Diamond Harbour

Plate 34– Bee Eaters are common birds found along the creeks and canals

Plate 35 – Verditer Fly catcher, Namkhana

Plate 36– Indian Roller , Diamond Harbour

f. Mammels: Among the mammals , languor , Jackal, Mongoose, Fox, Deer, Gangetic dolphin (*Plapanista gangetica*), fishing cat (*Felis viverrina*), palm civit (*Paradoxurus hermaphroditus*) deserves mention. Swamp Tigers are not found in our Study area.

Plate 37- Rhesus Macaques , fed on mangrove leaves, fruits, molluscs, and crabs , Chemaguri , Sagar Island

Plate 38- Squirrel are found in abundance

Plate 39– Gangetic Dolphin , while crossing Hugli River , Noorpur , South 24 Parganas to Geonkhali , Purba Medinipur , 22°12'33.82"N 88° 3'34.15"E. Sighted while surveying on 24rth November , 2020

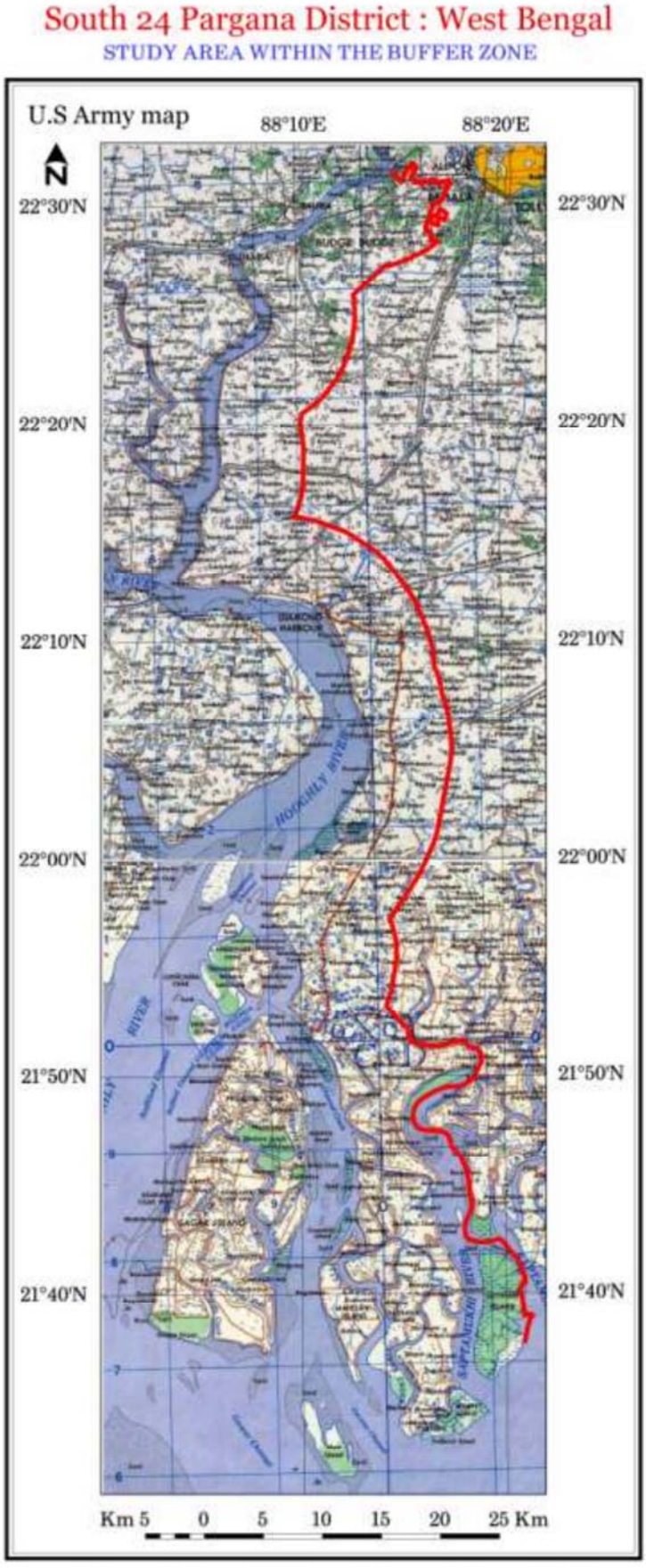
CHAPTER 4 – DOCUMENTING NATURE & PROPERTIES OF NATURAL HERITAGE

4.1. RIVER HUGLI AND THE HIGLI ESTUARY-

4.1.A. River Hugli – Hugli River after crossing Kolkata moves through Budge Budge , Falta , Kulpi , Daiamond Harbour and Kakdwip Block. From Kolkata till Achipur, Budge Budge 22°27'40.36"N, 88° 7'17.61"E it flows south and then from there - it flows almost due south, receiving the Damodar opposite **Falta Point** and the Rupnarayan opposite **Hugli Point** (22°12'44.80"N, 88° 4'13.80"E). These great tributaries deflect the stream to east for 8 miles, and have set up in it, just above the Rupnarayan, the dreaded moving' shoals known as the **James and Mary Sands**.. After Diamond Harbour the river resumes a southerly direction, until it debouches in the Bay of Bengal, its breadth at the point of junction being about 16 miles: its mouth is locally kuown as *Burha Mantreswar*. Shortly before it falls into the sea it bifurcates, the main channel passing west and another channel east of Sagar Island. This latter channel is called the **Baratala River** or **Channel Creek**, but is known locally as the **Muriganga**.; it is fed by several subsidiary channels or creeks and loses itself in the Bay east of Dhoblat. On the right or west bank the main channel receives the Haldi river from the Midnapore district opposite Mud Point, on the north of Sagar Island, and about 16 miles lower down the Rasulpur joins it from the same district. In its course along the boundary of the district the Hugli receives no important tributaries on its left bank, it's only feeders being the **Diamond Harbour** and **Khola Khali creeks** and the Falta, Nila and Harua Khals, all small streams.

During the rainy season the spill streams from the Ganges and the Chota Nagpur tributaries of the Bhagirathi pour down an enormous volume of water, which serves to scour out and maintain a deep channel. In the dry season, when there is no such influx, the river is largely fed by percolation, i e., by the underground infiltration of water into the deep trough which the river has scooped out for itself. In addition to these sources of supply, the Hugli is a tidal river, the tides running up strongly more especially during the dry season, when they provide water for navigation over the shoals; it is estimated that the tidal inflow during the four months of the dry season is more than double the total fresh-water discharge of the year. The greatest mean rise of tide takes place in March, April and May, and is about 16 feet; there is a declining range during the rainy season to a mean of I 0 feet, and a minimum during freshets of 3 feet. Navigation is rendered difficult, not only by rapid currents, but also by shoals and

shifting sandbanks. The James and Mary Sands, in particular, have an evil reputation for their peril to vessels making the passage of the Hugli. They lie between Hugli Point



Map 9- US Army map showing Location of Study Area

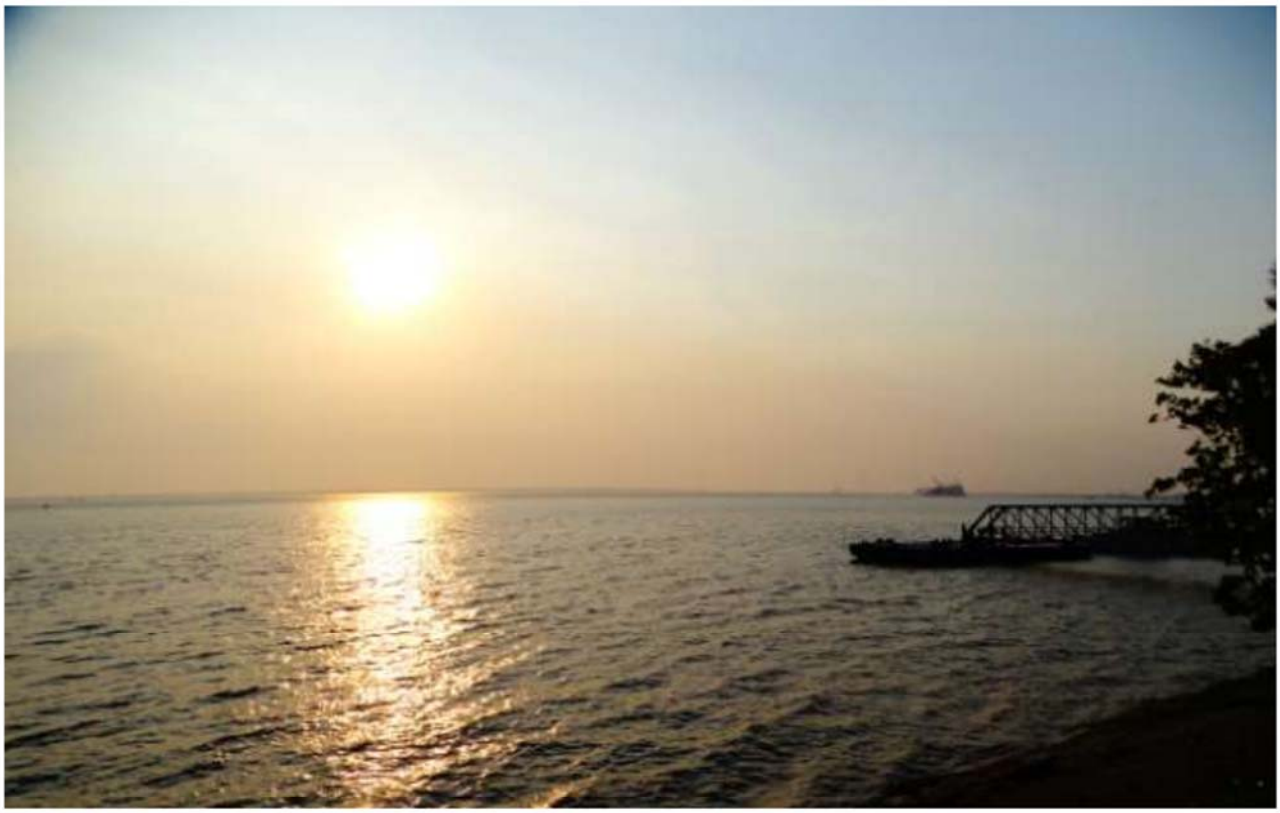


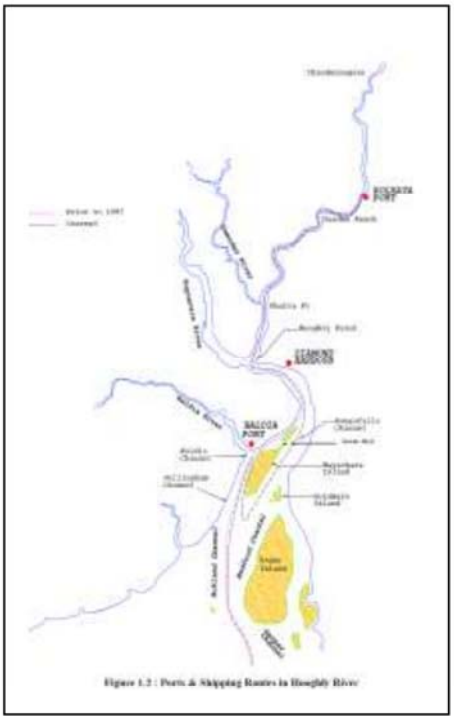
Plate 40– Diamond Harbour , Hugli River before joining Bay of Bengal , 22°11'11.29"N 88°11'18.17"E

Plate 41– River Hugli near Acra /Akra Ferry Ghat , northern boundary of South 24 Parganas. 22°30'45.55"N 88°12'34.47"E

and Geonkhali, and owe their formation to the Rupnarayan and Damodar. These rivers enter the Hugli on its right bank at a short distance from each other, and, arresting the flow of its current by their combined discharge, cause it deposit silt, which forms the shoal known by this name. The name itself is derived from the, Royal James and Mary, a ship which was lost here in 1694. Since then many ships and steamer have been wrecked on the sands. Among others, the Arcot and Mahratta steamers of the British India Steam Navigation Company, were lost in 1885, and the City of Canterbury in 1897, Above the James and Mary are other bars at Mayapur, Rajpur, Falta and Nainan, and below them are the Upper Belari, Lower Belari, Haldia, Gabtala, Middleton and Gasper.

4.1.B. Hugli Estuary- Hugli estuary is a funnel shaped estuary with very dynamic geomorphological features. The breadth and cross-sectional area at the mouth if 25km and 156250m2 and this decreases to 6 km and 36,799m2 at the head end. This estuary serves as the main entrance water ways for the main port of north eastern India Kolkata Dock system and Haldia Dock Complex. These are the only riverine port of India and stood second (after vizag) in container handling in the year 2007. This estuary is very important in the sense of its ecological diversity as it serves the nursery ground for several flora and fauna . The estuary consists of several bars, islands and a delta. The main features of the estuary includes Nayachara island,Ghoramara Island, Balari island, Jambu Island and Sagar delta. Mixing zones of the estuary extends up to Diamond harbour, about 80 km upstream. This estuary receives 4 small rivers - **River Damodar (Haora District) and Rupnarayan (Boundary between Haora and Purba Medinipur) at its head, and River Haldi and Rasulpur (Purba Medinipur) at the middle.** This estuary is very shallow, depth is only 6m on the average and nowhere deeper than 20m. (Biswas, 1985) This delta is ornamented with large number of tidal bars and tidal islands of which Sagar Island (South 24 Parganas), , and Nayachara (Purba Medinipur) are important. Sagar Island, the largest of the Sundarbans biosphere positioned at the mouth of the estuary and bifurcates it into two channels, the western channel is retained as Hugli and eastern is named as Bartala Creek or Muriganga. (Mukhopadhyay, 2007)

Map 10 - Hugli Estuary, High Resolution satellite Image



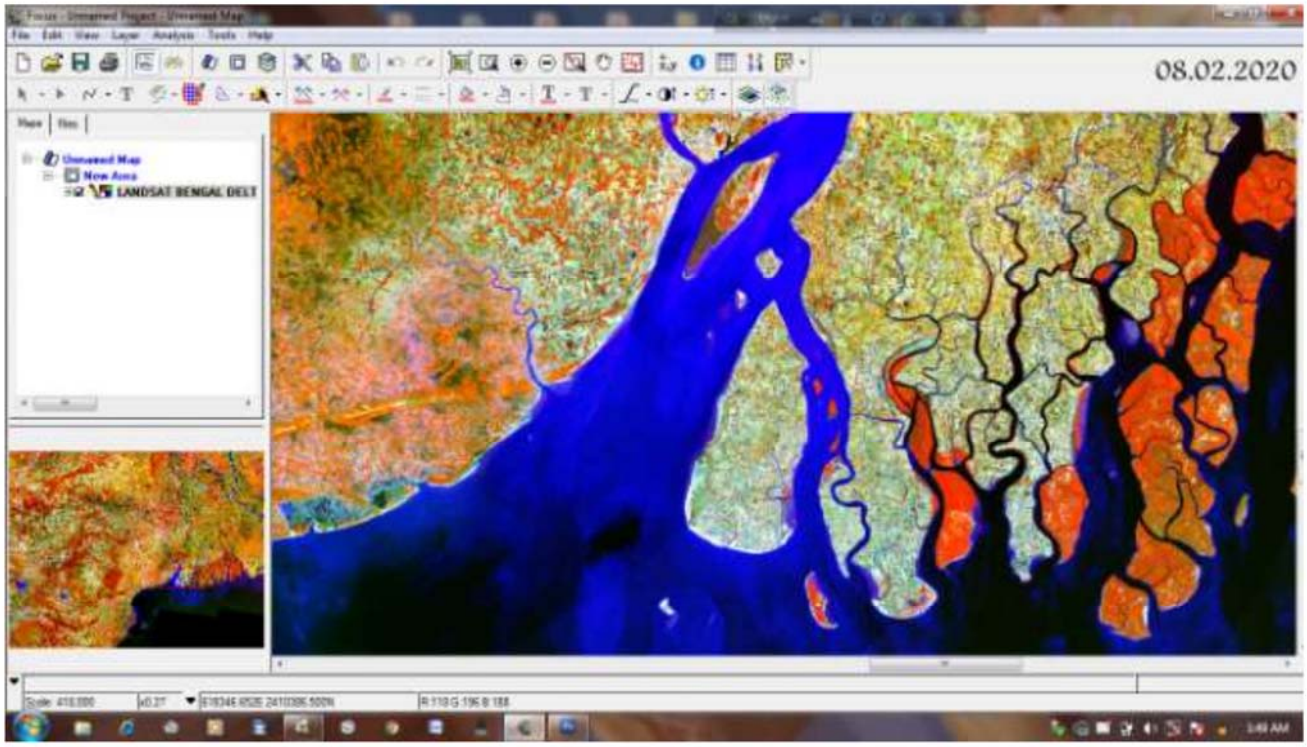
Siltation is severe in the downstream stretch of the estuary around the Haldia Port. The presence of the four major shallow patches or bars between Haldia and the sea , which frequently impeding navigation are;

i. Balari at 58km upstream of Sagar

ii. Jellingham at 38km upstream of Sagar

iii. Auckland at 20km upstream of Sagar

Jellingham and Auckland bars are the two bottle necks in the navigation channel through the Hooghly River and need to be monitored and dredged continuously. The sediment supply to the estuary is mainly from upstream river flow.



Map 11- Recent Landsat Image of Hugli Estuary , 8th February ,2020

Plate 42– Gangasagar beach , Sagar Island , 21°38'5.83"N 88° 5'10.18"E

Map 12 – High resolution Image showing Hugli Point

Plate 43- Hugli Point , Falta from where the river Hugli receives Rupnarayan River. 22°12'58.58"N 88° 4'14.10"E

4.2. OTHER CREEKS AND CANALS OF THE STUDY AREA

a. Saptamukhi River is a tidal estuarine river in and around the Sundarbans in South 24 Parganas district in the Indian state of West Bengal. The Saptamukhi originates near Sultanpur and flows between Kulpi and Mathurapur blocks. It has a connection with the Muri Ganga River and Deogra Khal. It falls to the Bay of Bengal with a wide mouth after traversing about 80 kilometres (50 mi)

Map 13 – High Resolution Image , Saptamukhi River

B. Muri Ganga River (also called Baratala River or Channel Creek) is a distributary of the Hugli in South 24 Parganas district in the Indian state of West Bengal. Before joining the Bay of Bengal, the Hugli bifurcates with one channel passing east of Sagar Island. This channel is called the *Baratala River* or Channel Creek. It is locally known as Muri Ganga. In ancient times this river used to be called as Rogues River , as it used to be infested with Mag pirates.

Map 14 – High resolution Image
Showing Bartala Creek , Muriganga

The Bartola river and Creek Channel of the Lower Hugli estuary are seen to be a hydrodynamic zone where the processes of sedimentation, erosion and accretion are active

Plate 44 – 8.No. Lot Jetty near Muri Ganga River , Kakdweep 21°53'26.68"N 88° 9'54.57"E

Plate 45 – Muri Ganga River , 21°53'33.93"N 88°10'2.22"E

C.The Hatania Doania 21°45'45.24"N, 88°13'17.69"Eriver flows through the district of South 24 Parganas, West Bengal province of India. Namkhana is on its north bank and Narayanpur is on its south bank. There is a ferry service to cross the river and a vessel service for vehicles. A bridge was in the process of construction, and has since been constructed and inaugurated

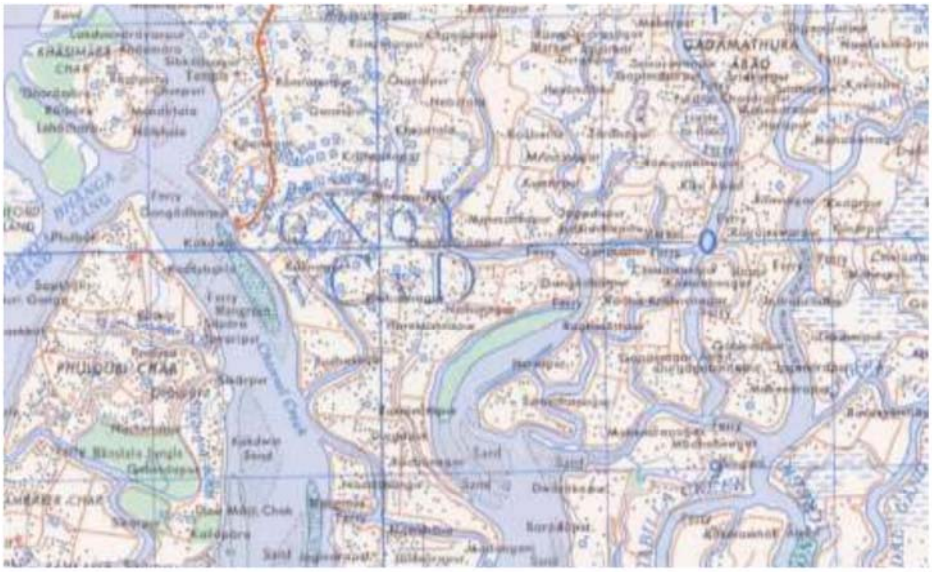
Plate 46- Hatania Doani River , Namkhana

Map 15 – Hatania Doania , High Resolution Image

Plate 47– Hatania Doani River , Confluence with Muri Ganga ,Namkhana
21°45'48.31"N 88°13'50.29"E

Plate 48– Fishing Trawlers at Hatanaia Doani River confluence with Muri Ganga ,
21°45'45.98"N 88°13'19.39"E

D.Kalnagini Khal , Kakdwip –The Saptamukhi Estuary braides right at the sea face into the arms - The East Gully and The West Gully moving up around Lothian Island. The Two gullies nearly meet each other at the shallow ridge called Susni Char at the northern tip of Lothian Island but again get separated them around the Prentice Island Near Susni Char, the two gulies remain separated at low water but near about high water, they combine together with a liitle croos flow along Susni Char. At the northern extremity of the Prentice Island, the East and West gullies join together again to form the upper reaches of Saptamukhi River.The Saptamukhi is wide and comparatively shallow and as a result has a number of shoals. One such big shoal separates the main Saptamukhi stream from the Ghugudanga blind creek. Further up the Saptamukhi is known by the name Ghigudanga Gang which ultimately



Map 16- Kalnagini Khal, US Army Toposheet

Plate 49 – A fishing trawler in Kalnagini River, Kakdweep, 21°48'34.04"N 88°12'26.61"E

branches off into two arms -The Banstala River towards the north and the Kalnagini Khal towards the West. Thus the Banstala - Ghugudanga Gang - Saptamukhi West Gully has more or less formed a continuous arm, whereas the East Gully being a distributor remains on the other side ofthe Prentice and Lothian Island. In the course of this river from inland side towards the sea, there are several Lateral branches or inter connections with adjacent river system on other side.

Plate50 – Kalnagini River
21°48'45.03"N 88°12'51.75"E

3.ISLANDS OF THE STUDY AREA -

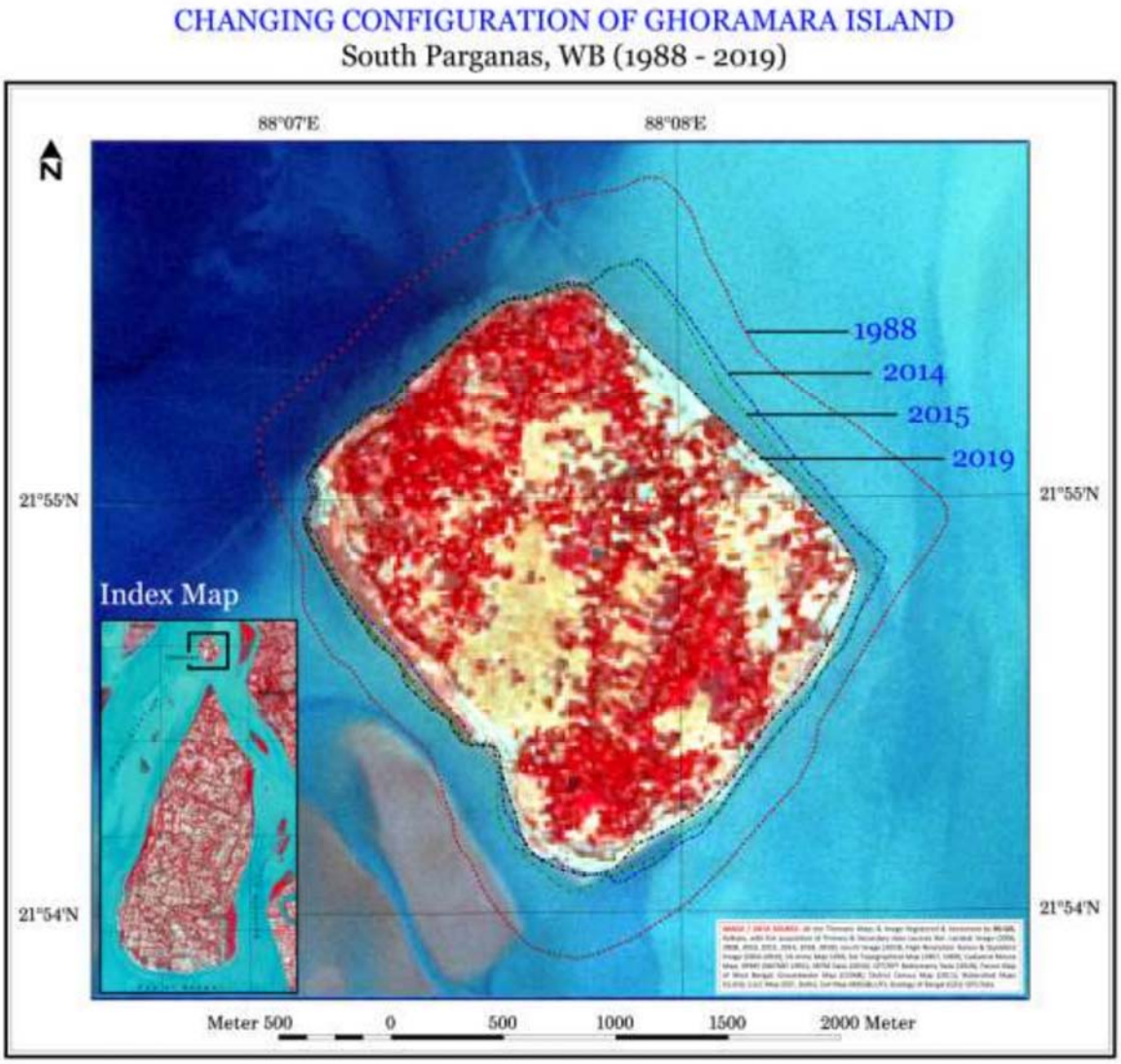
The Hugli estuary is a funnel shaped coastal plain estuary and is one of the largest estuary of the river Ganges. The morphometric setting of the estuary is the product of continuous fluvial sedimentation by a series of para-deltaic lobe progradation systems developed on the western shelf margin areas and eastern basinal troughs of the Bengal basin tectonic frame, over the entire Holocene period. The quaternary sediments are underlain by the tertiary sediments indicating an accumulation in a subsiding tectonic trough. Looking at the geological setting, the estuary itself occupies the Eocene hinge zone. Sagar is the largest island of the Sundarban, positioned at the mouth of the Hugli estuary and divides it into two channels, the western channel is retained as Hugli and eastern is named as Muriganga.

A. Ghoramara - Ghoramara island is located north of Sagar Island. Ghoramara and Sagar were joined and formed a single island till 1903, when Ghoramara got separated from Sagar and stabilized as a separate island. It is known as the "sinking island". Located 150km south of Kolkata in the Bay of Bengal's Sunderban delta, the island, once spanning more than 20sq km, has been reduced to an area of merely 5sq km. It may be due to anthropogenic activity or global environmental changes. This includes degradation of the mangrove and erosion-accretion, problems regarding the mixture of fresh and salt water due to sedimentation in the creek and frequent tidal floods. This degradation may have started as early as 1777, when reclamation started by constructing earthen embankments. The island surface level was below the high tide line. The construction of the embankment restricted the saline water flood on the island. Some of the islands, e.g. Lohachara and Suparibhanga disappeared entirely, while Kabasgadi shifted from its original position and attached to the main land of India; on the other hand Balaribar Island is gradually emerging; it plays an important role in the estuarine hydrodynamics of the area. This may determine the severity of erosion and form a scenario of accretion on the estuarine islands.

Change detection study of Ghoramara Island over a period of 100 years. SOI Toposheet – 79 C/1 of 1924 , US Army Map , and Multitemporal Satellite Images (Landsat FCC, 1988, 2019) were taken in Remote Sensing and GIS Platform to generate a Change Detection Study of this sinking island.

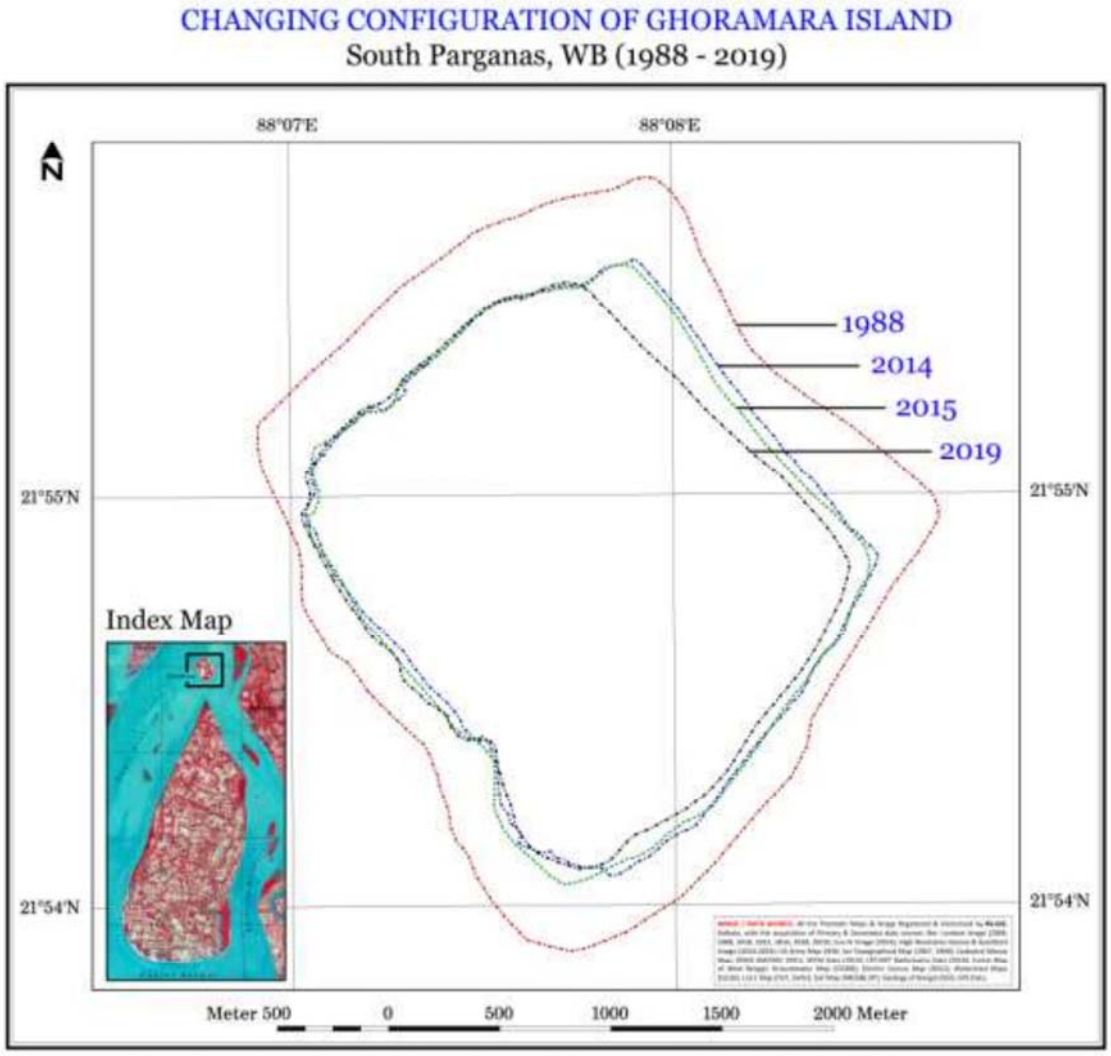
Map 17 - SURVEY OF INDIA 79 C/1 West Bengal Hooghly Estuary Kakdwip Sagar Island 1924 map

Map 18-High resolution Image , Ghoramara island



Map 20 – Changing Configuration of Ghoramara island

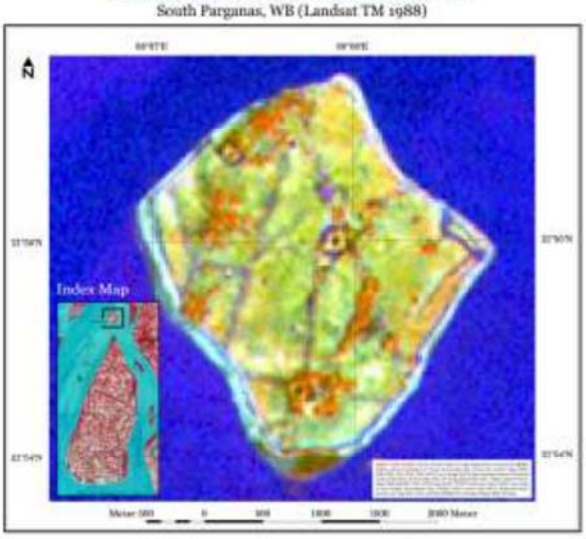
Location	Timeline	Source Image	Area
Ghoramara	1955	US Army Map	18.38sq.km
	18th feb ,1988	Landsat Image (FCC)	6.35sq.km
	20148th feb	Landsat Image (FCC)	4.23 sq.km
	2015,15th March	Landsat Image (FCC)	4.21 sq.km
	2019, 15th Feb	Landsat Image (FCC)	3.89 sq.km
Lohachara	1955	US Army Map	8.34 sqkm
	1980		Inundated
Bedford Island	1955	US Army Map	7.46 sq.km
	Not Clear		Inundated



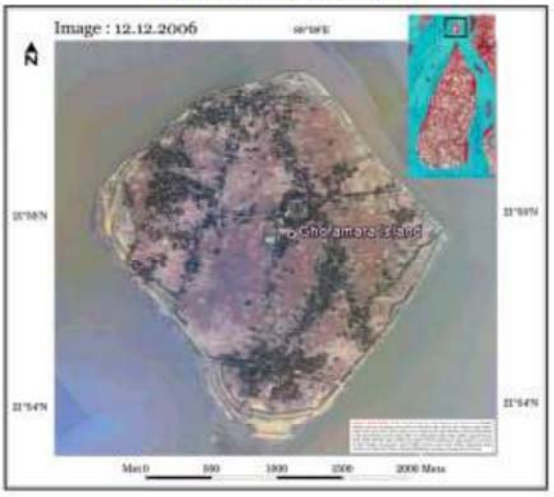
Map 20 – changing Confiruration of Ghoramara Island, 1988-2009

Plate 51 : Ghoramara Island – Devastated shoreline of Ghoramara Island after Amphan 2020, 21°54'31.89"N 88° 7'25.50"E

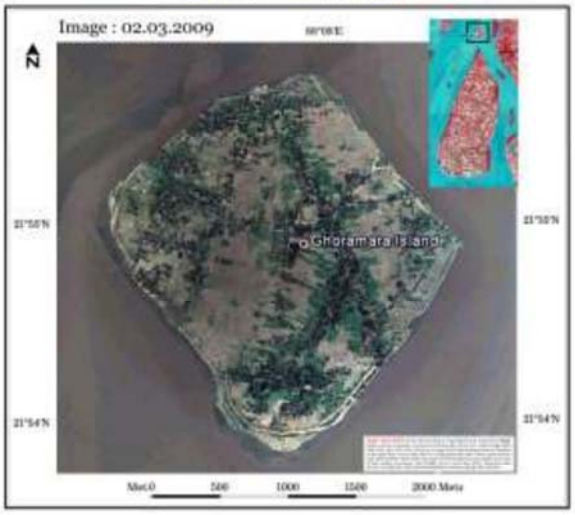
CHANGING BOUNDARY OF GHORAMARA ISLAND
South Parganas, WB (Landsat TM 1988)



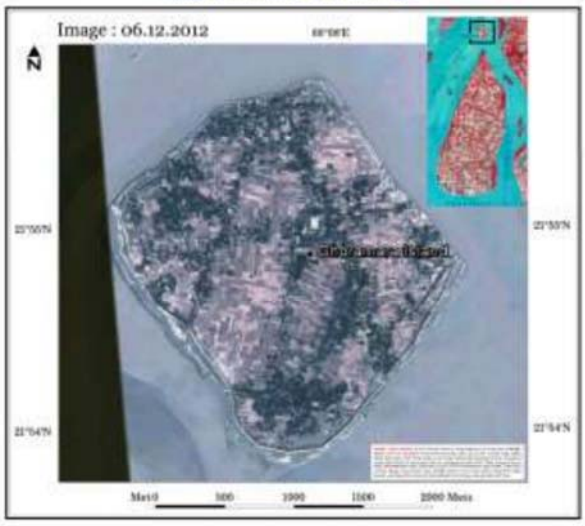
CHANGING BOUNDARY OF GHORAMARA ISLAND
High Resolution Ikonos Image



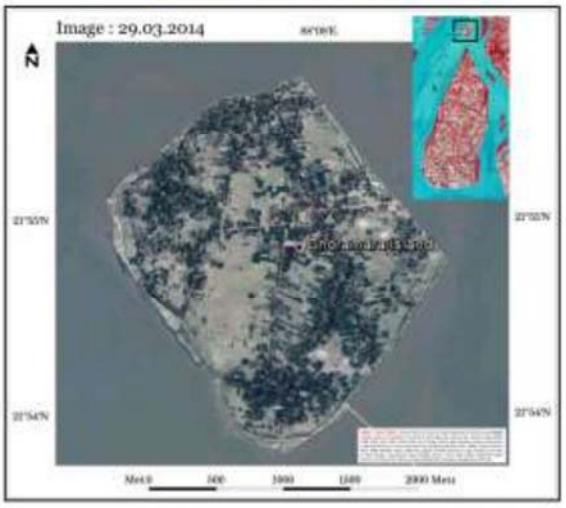
CHANGING BOUNDARY OF GHORAMARA ISLAND
High Resolution Ikonos Image



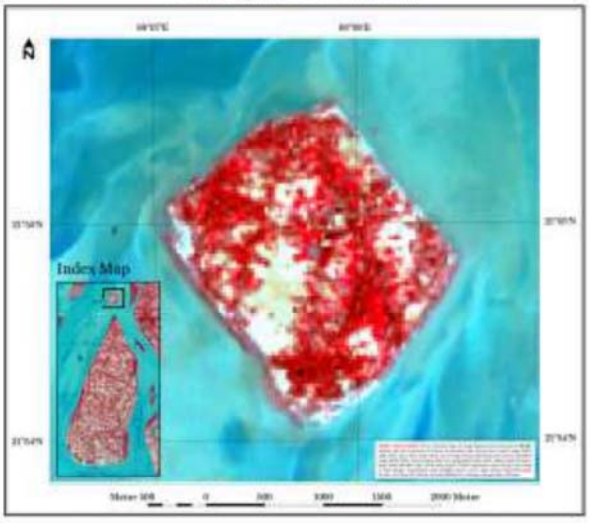
CHANGING BOUNDARY OF GHORAMARA ISLAND
High Resolution Ikonos Image

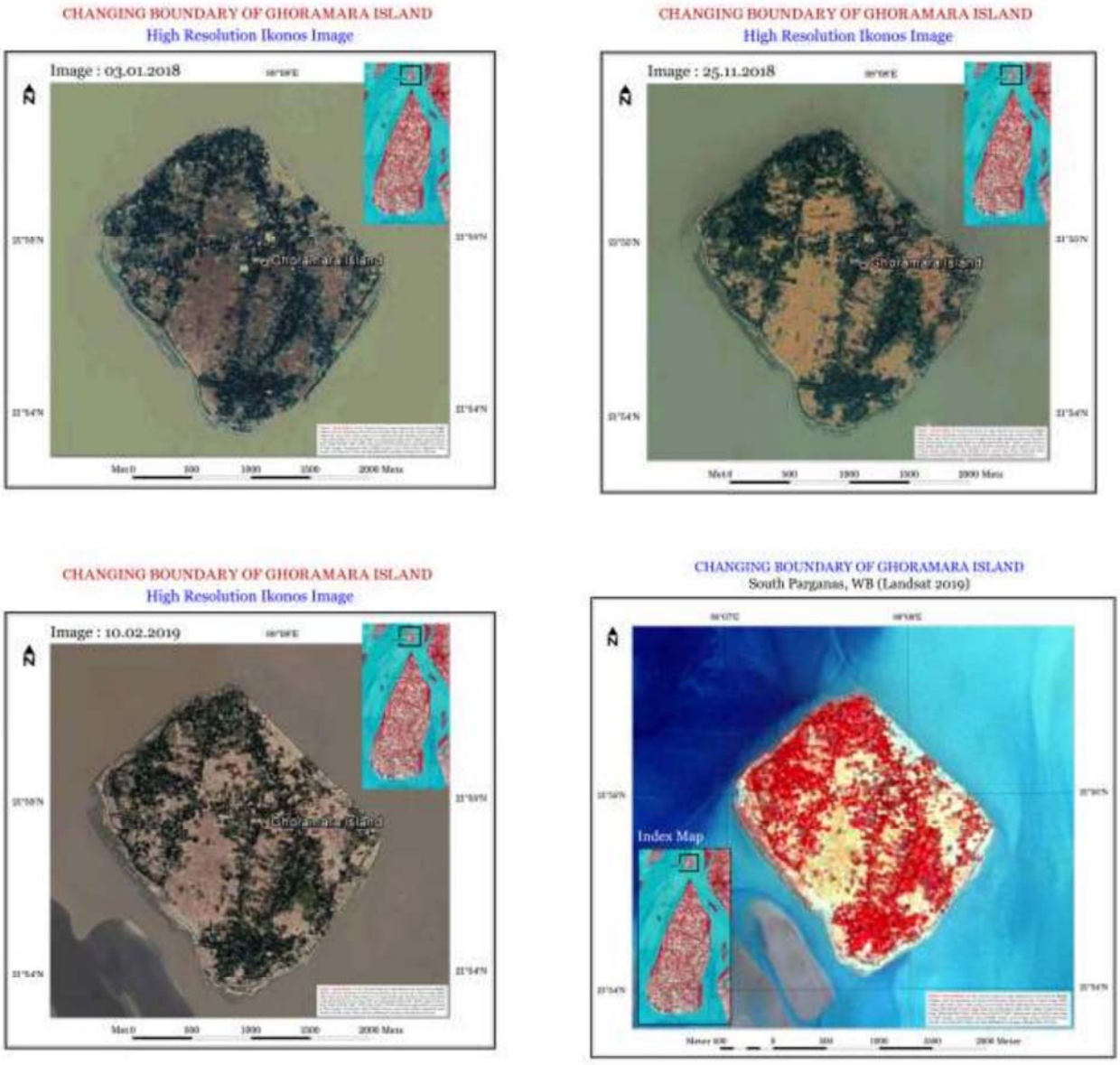


CHANGING BOUNDARY OF GHORAMARA ISLAND
High Resolution Ikonos Image



CHANGING BOUNDARY OF GHORAMARA ISLAND
South Parganas, WB (Landsat 2015)





Map 19-28- Satellite Images of Ghoramara Island showing changes in the Island Configuration

Plate 52 – Reaching Ghoramara Island

Plate 53 – Ghoramara Island , devastated after Amphan Cyclone 21°54'34.12"N 88° 7'22.13"E

Plate 54 – Mud Houses in the Island , 21°54'40.41"N 88° 7'25.28"E

B. Lohachara Island/Bedford Island- Lohachara Island was an islet which was permanently flooded in the 1980s. It was located in the Hugli River as part of the Sundarban delta in the Sundarban National Park, located near the Indian state of West Bengal. The definite disappearance of the island was reported by Indian researchers in December 2006, which led to international press coverage. No specific study was ever done to prove that the island was permanently inundated (and not eroded away) because of sea level rise. The islet is one of a number of "vanishing islands" in India's part of the delta: in the past two decades, four islands – Bedford (or Suparibhanga), Lohachara, South Talpatti Island (disputed island between Bangladesh and India), and Kabasgadi – have been permanently flooded. Of them, only Lohachara was an inhabited island where more than 6,000 people used to live. The loss of land has created thousands of displaced people in the area who were forced to move to the mainland.

There are multiple causes of the disappearances of islands in the delta, including sea-level rise, coastal erosion, cyclones (while the number of cyclones has decreased, their intensity has increased), mangrove destruction and coastal flooding.

In 1974 the Farakka Barrage began diverting water into the Hoogly River during its dry season. During each monsoon season almost all the Bengali delta is submerged, much of it for half a year. The sediment of the lower delta plain is primarily advected inland by monsoonal coastal setup and cyclonic events. One of the greatest challenges people living on the Ganges Delta may face in coming years is the threat of rising sea waters caused by subsidence (sinking) in the region. Residents have to be careful building on the river delta, as severe flooding sometimes occurs.

A 1990 study noted "There is no evidence that environmental degradation in the Himalayas or a 'greenhouse'-induced rise in sea level have aggravated floods in Bangladesh."The Bengal Basin is slowly tilting towards the east due to neo-tectonic movement. As a result, the salinity of Bangladesh Sunderbans is much lower than that of the Indian Sunderbans.

Map 29 – US Army map showing the island configuration

Map 30 – High Resolution Image , Ghoramara Island,

C. Shiber Char – In 1984 , Lohachara & Bedford islands were inundated and a new Island was formed in Muriganga adjoining Kakdweep. This new island is known as Shiber Char. Within 35 years , this char or island has gained it's size.

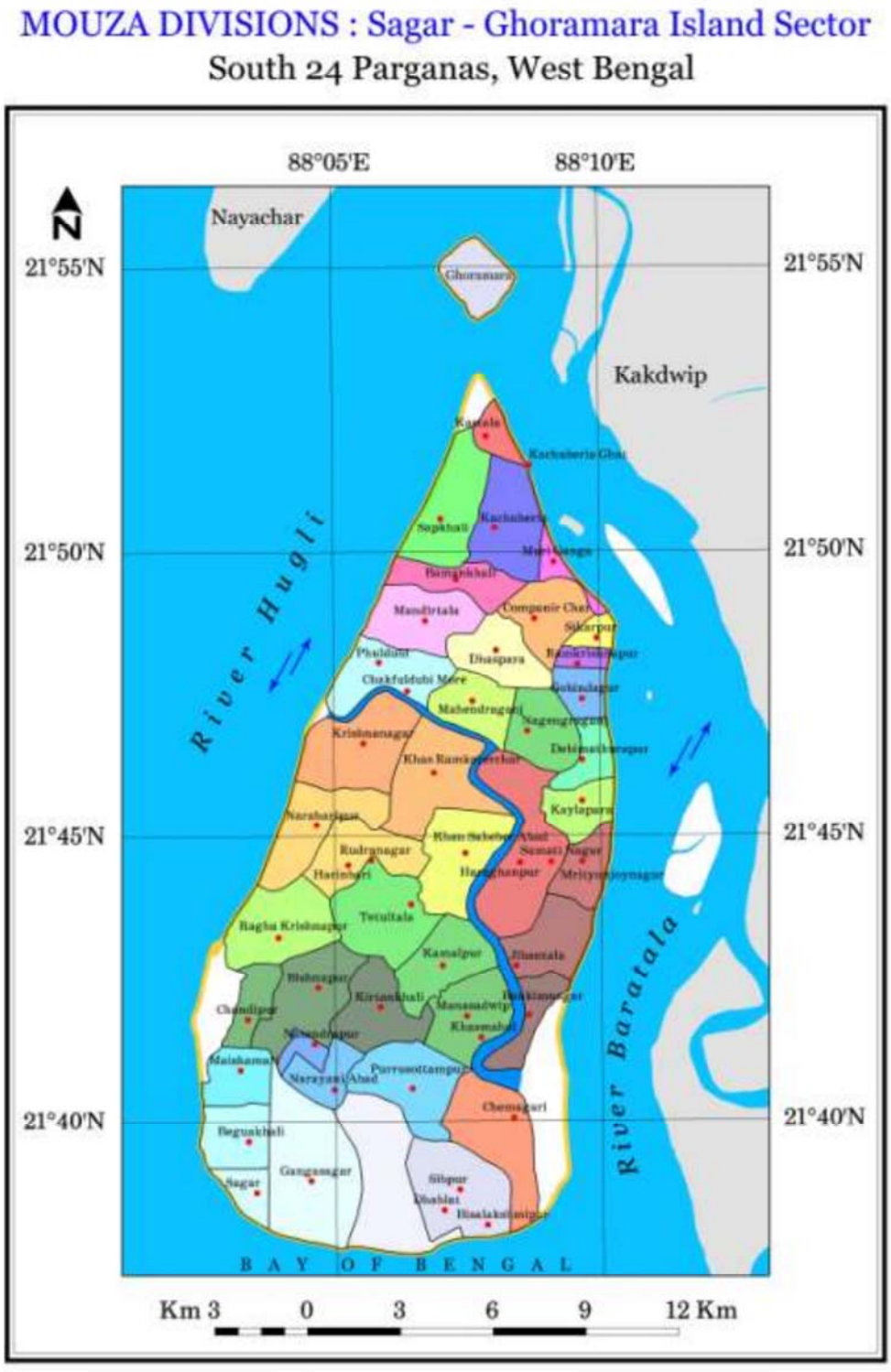
Map 34- 1984 - High Resolution Satellite Image

Map 35 -1997- High Resolution Satellite Image

Map 36 – 2006, Shiber char

Map 37- 2019, High Resolution Image

D. Sagar Island -Sagar Island in India (21°53'6.45"N / 88° 7'45.66"E. To 21°37'49.67"N to 88° 6'30.76"E) is the largest island of the Sundarbans deltaic complex. The Hoogly river is to the north and west, the Muriganga distributary in the east and the Bay of Bengal in the south The north-south length of the island is 30 km. It has a maximum width of 12 km. The average elevation of the island is 6.5 m above the mean sea level (Mukherjee 1983). Fluvial, marine, tidal and aeolian processes are the chief agents actively shaping the narrow coastal belt.



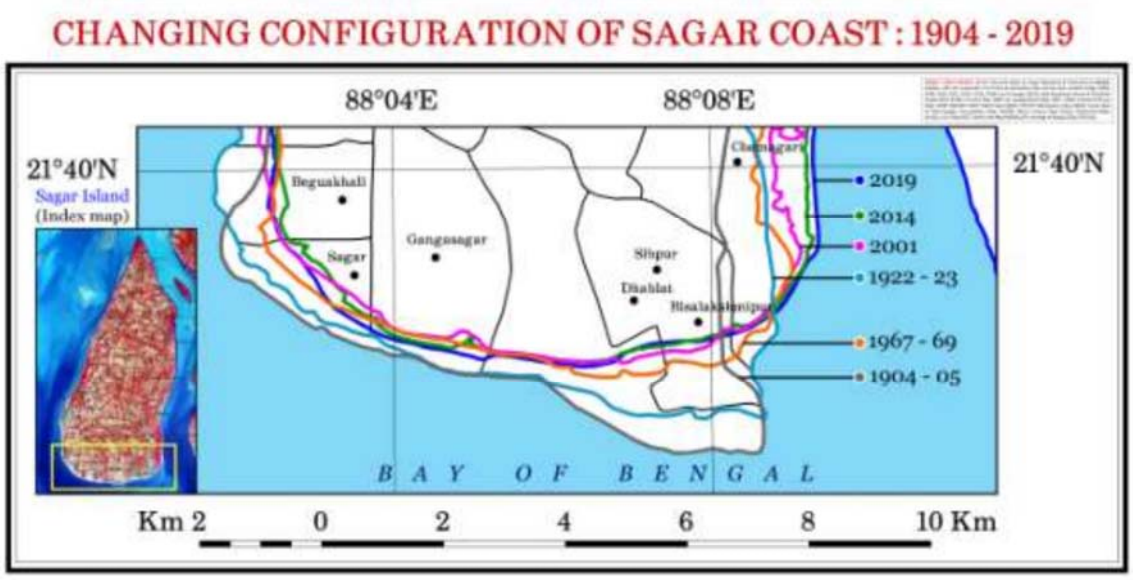
Map 38 – Administrative Map of Sagar Island

Plate 55 – Kachuberia Jetty , 21°51'30.60"N 88° 8'40.30"E the Entrance Point of the Island , along Muri

Plate 56– Ganga Sagar Creek, 21°38'3.83"N 88° 5'5.29"E joining with Bay of Bengal,

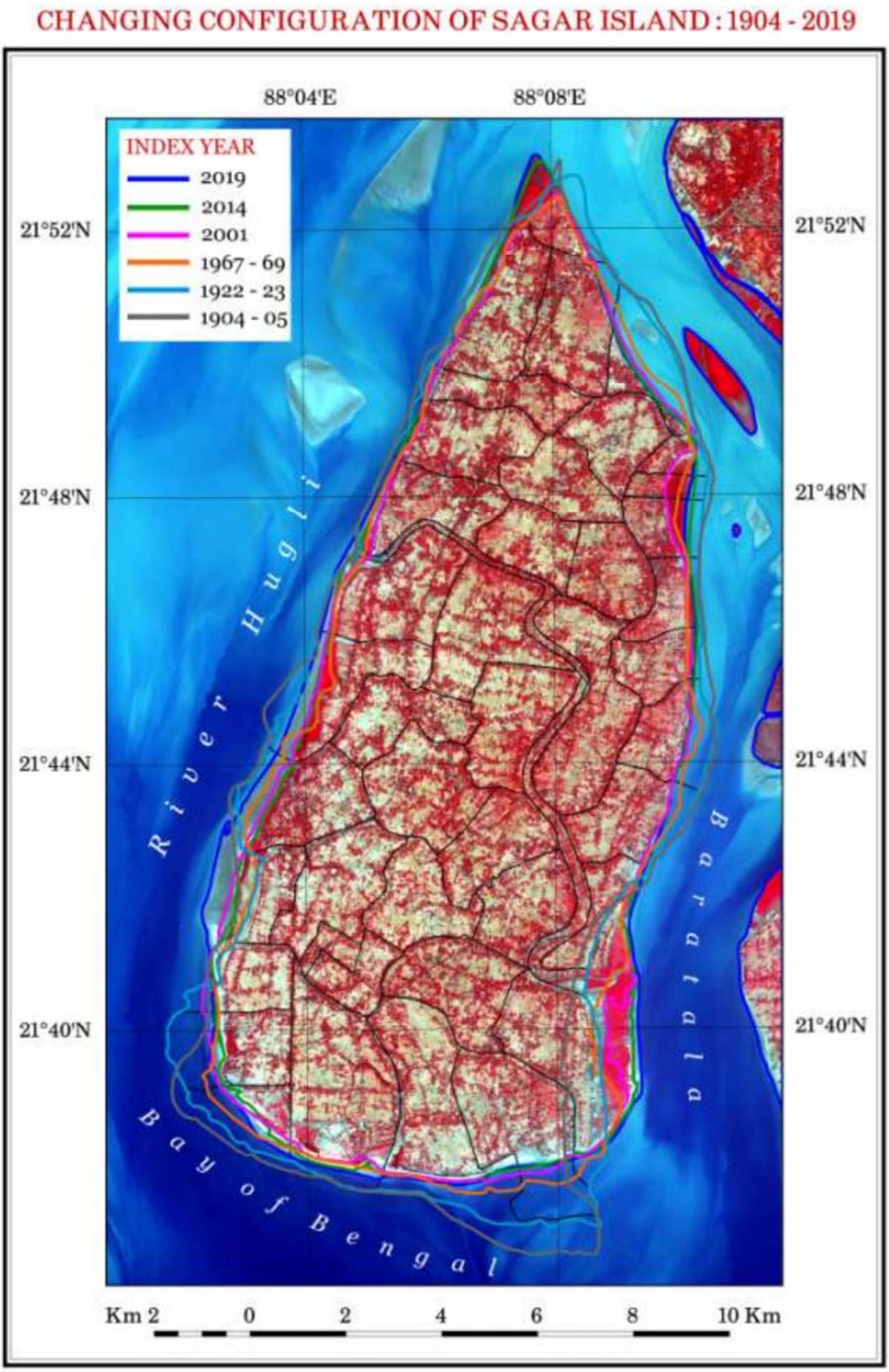
The earliest documentation of Sagor Island is found in the 1767 Map of James Rennel where the morphometry of the island is completely different from what we see it now. For this project we have used SOI Toposheet of 1904/05 as our Base Map. We have overlaid the Toposheet of 1924/25, then US Army Map of 1955, SOI Toposheet of 1967-68 and then the Landsat Images of 2001, 2014 & 2019. There is a constant change in the island configuration.

Name of the Island	**Source Image**	**Year**	**Area** (sq.km)
Sagar Island	SOI TOPOSHEET	1904/1905	207.10
	SOI TOPOSHEET	1922/23	258.58
	US ARMY MAP	1957/58	235.05
	SOI TOPOSHEET	1967/69	234.78
	LANDSAT FCC	2001	232.47
	LANDSAT FCC	2014	234.16
	LANDSAT FCC	2019	245.72

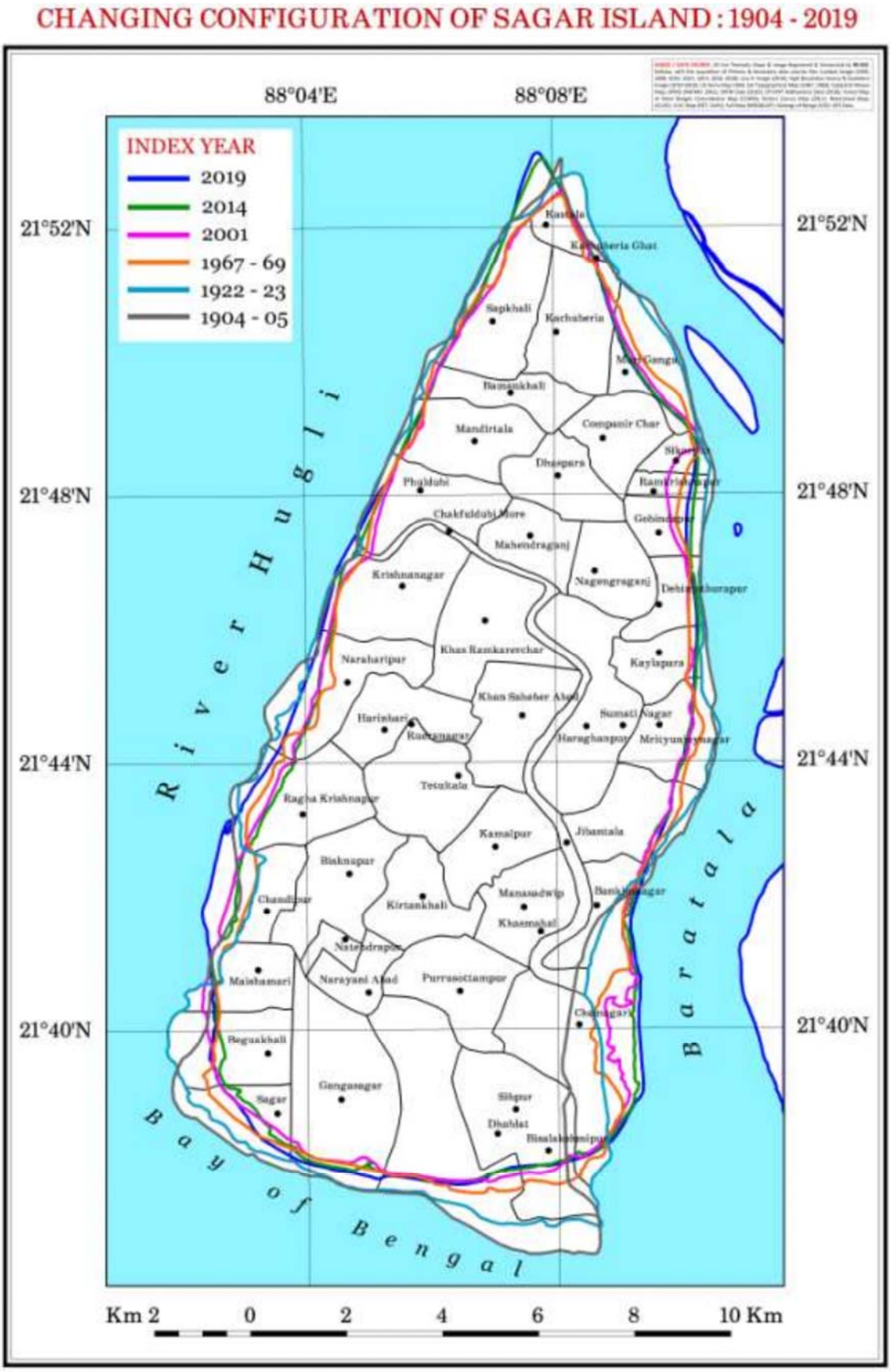


Shoreline erosion and coastal flooding are resulted from the reduction of tidal prism and associated chain effects, as hydraulic adjustment of rising water level, wetland restoration system in the nature and increasing risk hazards. Thus, the existing defense structures are unable to protect the shorelines and low-lying areas from erosion and flooding related problems in Sagar Island at present. As with many other tidal channels, estuarine channels of Hugli and Muri Ganga have experienced periodic shift in their position at Sagar Island. Such channel movement has initiated a new set of erosionproblems, as was the case at Mandirtala and Muri Ganga points of Sagar Island. Beguakhali and Dublat-Shibpur-Boatkhali sections of the island are among worst affected areas by erosion and salt water flooding along the Bay of Bengal shoreline.

Map 39 – Changing configuration of sagar island



Map 40 – Landsat Image , FCC showing changing configuration of Sagar island (1904-2019)

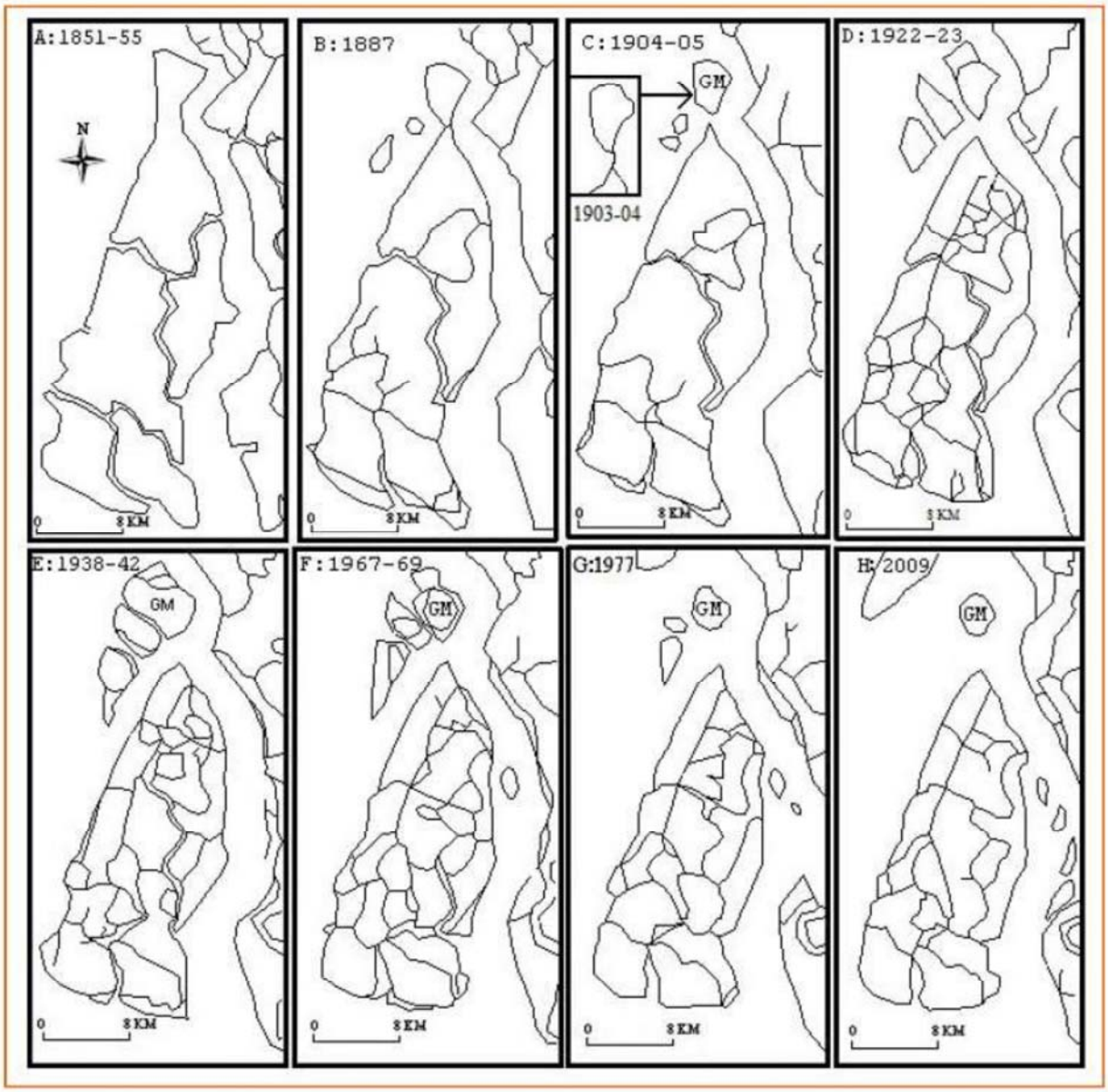


Map 41 - – Administrative map , FCC showing changing configuration of Sagar island (1904-2019)

History of Evolution - Sagar (21° 37′ to 21° 52′ N and 88° 02′ to 88° 11′ E) has evolved during the period between 5,000 and 2,500 years BP. During 17th and 18th century there were a numbers of different islands emerged as a fairly coherent unit, separated by narrow tidal creeks (Rivers of Bengal, Vol. II, Part-II). In the early maps (1687, 1690, 1720, 1785) the southern part of the island (present Mahishani-Beguakhali-Gangasagar region) had been named as the Sagar proper and the other parts had been named as Cox's island (Bahirplot region), Rogue's or Dog's island (Radhakrishnapur-Harinbari area) and Clive's island (rest of the present day Sagar). Among these, the island originally known by the name Saugor was probably separated by the widest inter island creek or water body (Rivers of Bengal, Vol. II, Part-II: 1785-Ritchie and Lackam's survey and 1831-Hodge's survey).

During its evolution, the island has faced the incidence of accretion and erosion subsequently. In 1904-05 and 1922-23, major accretion took place along the island's southeastern part facing the **Baratala.** Sagar showed a major phase of erosion between 1922-23 and 1967-69, though erosion in certain portions was balanced by accretion in other portions. The rate of erosion markedly reduced post 1967-69 as accretion occurred at its south-eastern and south-western parts, facing the Baratala and the Hugli respectively. The southern seaboard section of the island was subjected to continuous erosion all through the century, barring some progradation between 1942 and 1967-69 (Bandyopadhyay et al., 2004). It evolved in its present configuration during 1967-69. During 1922-23 the island had 256.78 km2 areas. In the year 1967-69 it became 233.10 km2 and during 2001 it became 230.64 km2 . In 2010, it again reduces to a size of 225.59 km2 area. The area indexes for the year 1967-69 and 2001 was 90.8 and 91.5 respectively. Ghosh et al, (2002) have stated that between 1989 and 1995 the land loss through erosion was 3.88 km2 . Bandyopadhyay (2000) has stated that since 1860 nearly 71 km2 , which is equal to one fourth of the island area, has been eroded .

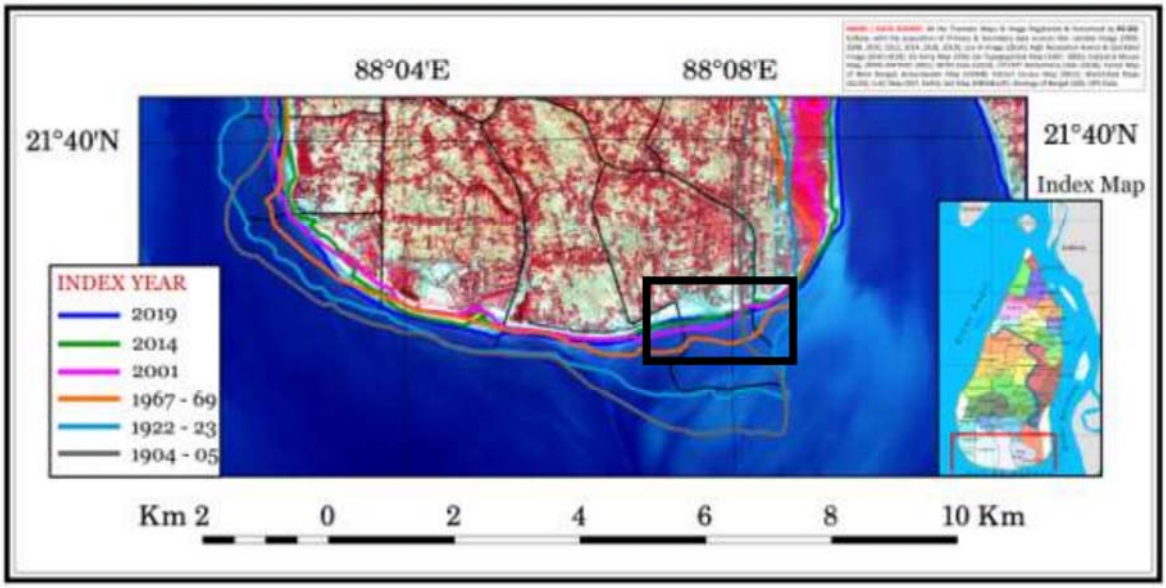
The estuarine islands evolve, enlarge and dissipate due to sediment reworking in a high energy cyclone dominated macrotidal environment. Roy (1969) suggested that the movements of the tidal channels and sand ridges of the estuary follow a 90 to 100 year cycle. Bandyopadhyay's study (2000) also admits that the accretion-erosion trends of the islands situated on the tidal sand ridges are also cyclic and follow a rhythmic pattern operating on a similar time scale. However, caution should necessary in its application as long periodical observation is needed to establish it validity.



Map 42 - Evolution of Sagar island: 1851-55 to 2009 (Modified after Bandyopadhyay et al., 2004)

Administratively , **Sagar block** has lost Khasimara, Bishalakshipur and Bedford island between 1922-23 and 2001. Other severely affected mouzas were: Ghoramara (73 percent), Muriganga (65 percent), Sagar (57 percent), Ramkrishnapur (48 percent), Kastala (44 percent), Gobindapur (41 percent). On the other hand accretion took place in Bankimnagar (77 percent), Chandipore (50 percent) and Chemagari (21 percent) mouzas with some other interior mouzas that gained from deterioration of the **Chemagari creek.**

Plate 57 – Shibpur _ Boatkhali , South Eastern coast of Sagar Island . The most vulnerable portion of the Island in terms of Coastal Erosion .



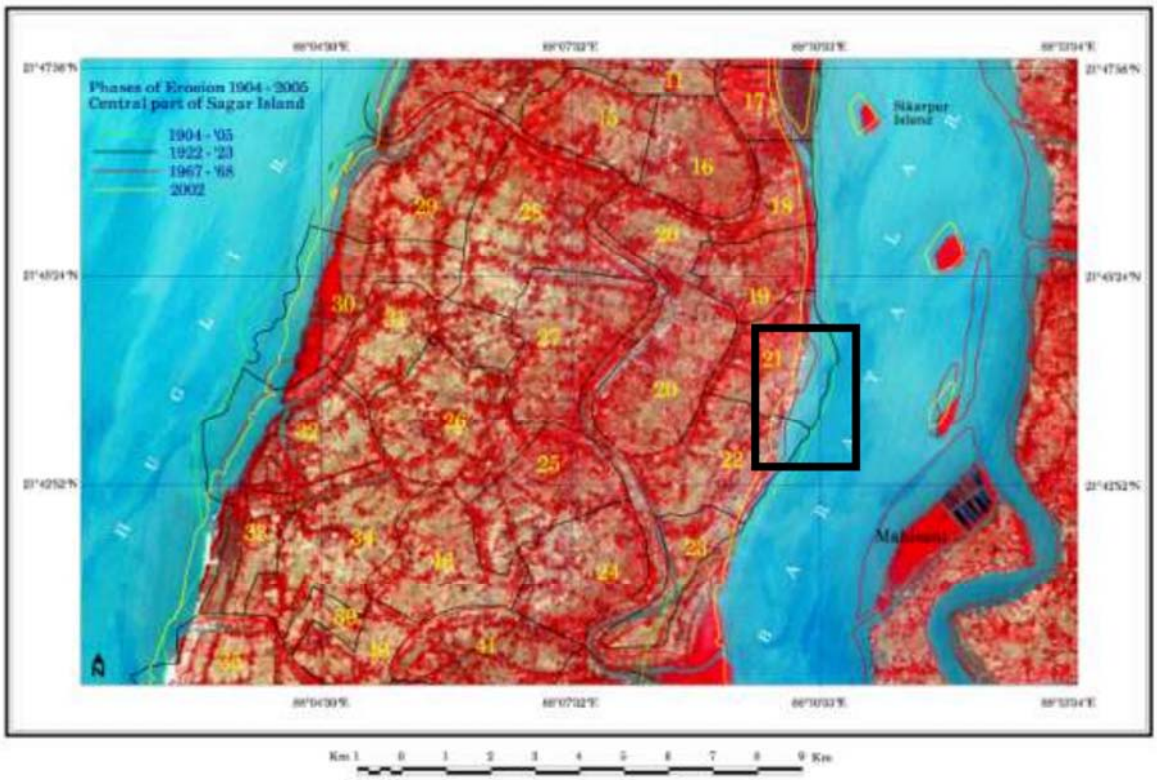


Plate 58– Vulnerable shoreline along Muri Ganga in the Eastern Part of Sagar island 21°42'25.30"N 88° 9'14.04"E

Plate 59- Beguakhali Beach with Embankment done after Aila Cyclone

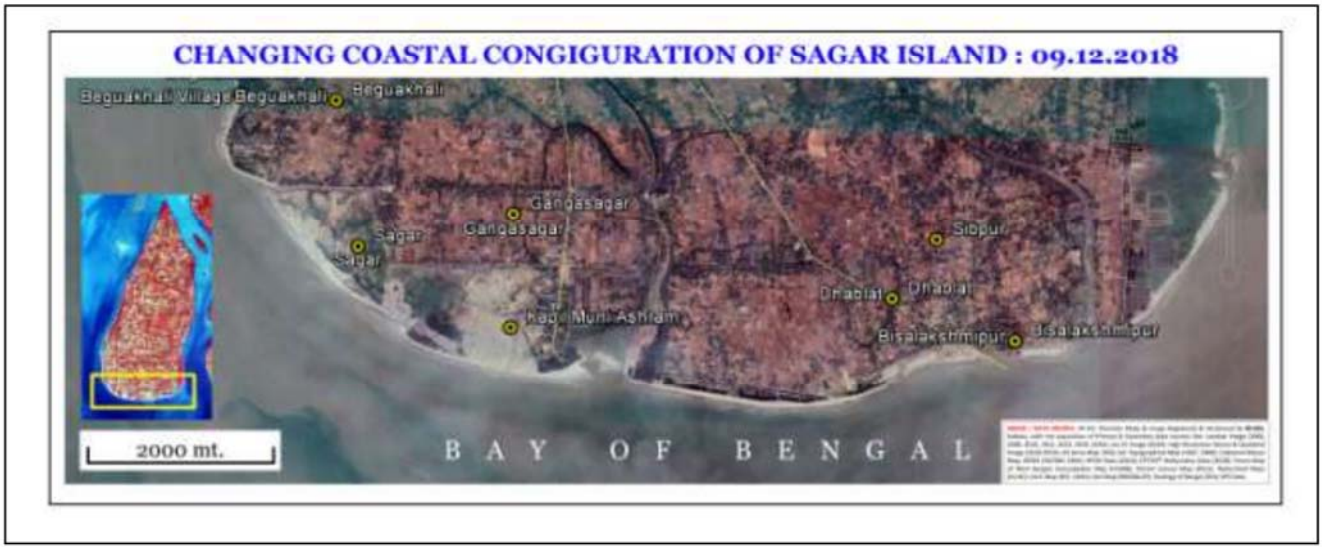


Plate 60- Vulnerable Beguakhali Coast , South Western part of the Island . 21°39'20.39"N 88°

E. Baratala Group of Islands - In the Baratala branch (known as Channel creek in early maps and charts), east of Sagar island of the Hugli estuary, a number of small islands appeared and disappeared over the years. Their number and combined size were quite small up to 1922-23 (1904-05: one and 0.31 km2 ; 1922-23: one and 1.33 km2) and reached maximum values in 1967-69 (five and 1.33 km2). Interesting fact is that when accretion took place in islands of the Baratala, most of the erosion of the eastern Sagar island found between 1922-23 and 1967-69. The width of the Baratala north of Namkhana increased from 2.1 km in 1904-05 to 4.8 km in 2001. Like Rangafalla East, parts of Kabasgadi island got fused to the left bank of the estuary between 1967-68 and 2001. In future, Shikarpur West may also have the chance to do the same to eastern Sagar (Bandyopadhyay et al., 2004).

Map 43 – Bartala creek Islands

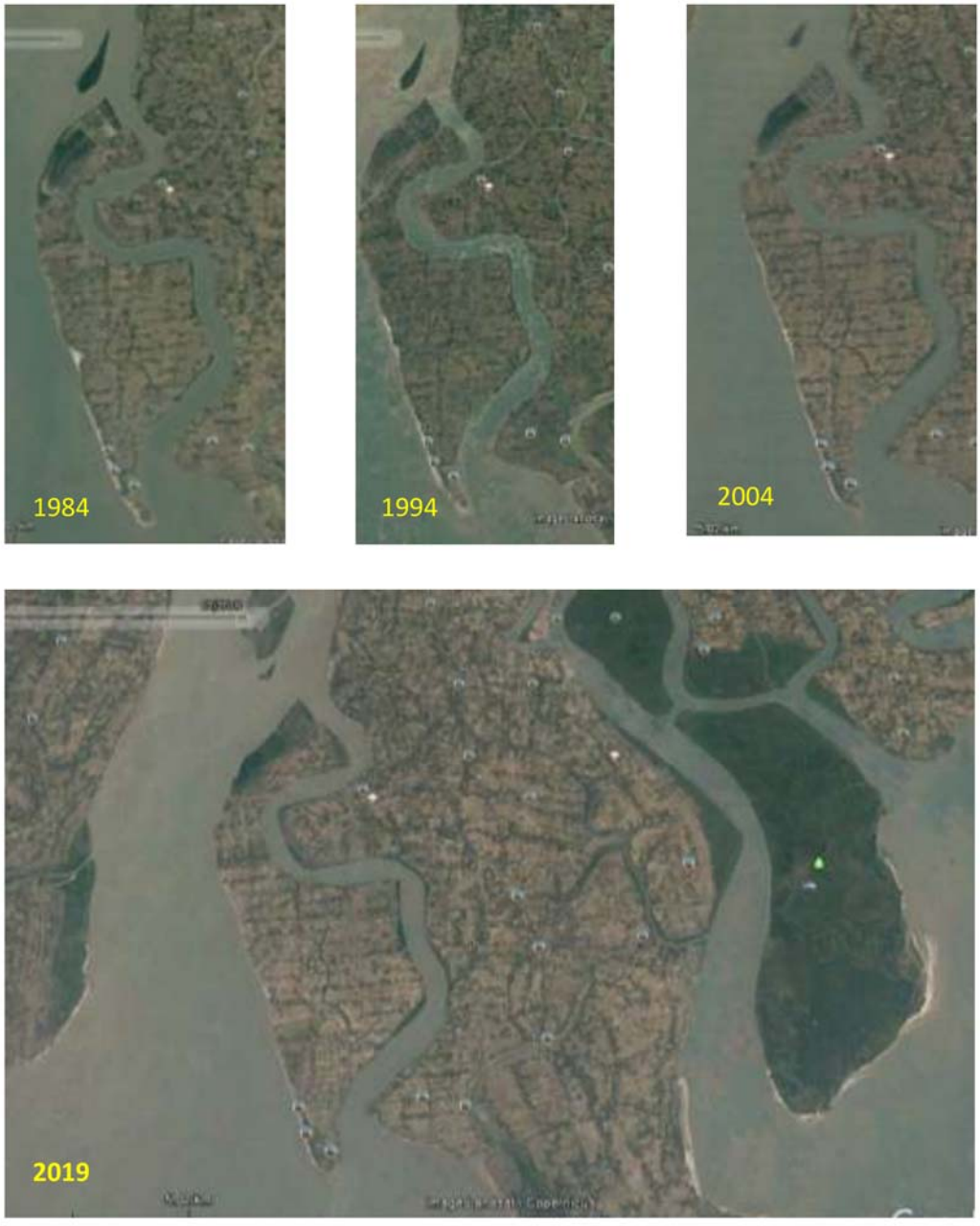
e. Jambu- Jambu is an outer estuarine island located about 10 km offshore in the south-west corner of the Sundarban. The island is located on a tidal sand ridge named Sagar Sand. A cycle of emergence and submergence is associated with this island. It was recorded as Edmonstone in 1817. According to Horshburgh, the island grew in 1817 from a half tide sand bank to an island of two miles in length and half a mile in breadth and affording a supply of fresh water. It was adopted as a station where a pilot resided in 1820 and in 1825 a proper house was built on it. A cyclone in May 1830 commenced to destroy it and it was abandoned as a pilot station in 1831. Cyclone during 1833 had divided the island into two parts and by 1841 it had completely disappeared. The dynamic island reappeared southwards in 1888, referred to as New island in 1922-23 by SoI topographical sheet (now known as Jambu).

During 1904-05 it had 0.58 km2 area. During 1967-69 it enlarged to 9.02 km2. After that it again started eroding and in 1986-88 it became 6.25 km2. In 2001 the partly reclaimed island has 4.60 km2 areas to exist (Bandyopadhyay et al., 2004). In 2009, Jambu became 4.98 km2 in its areal extent.

F. Mahisani Island /Moushuni Island -

In between MuriGanga or Bartala Creek and Pitt's Creek (Chinai Nadi)we find a big island called Mahisani Island . But with time , the name has transformed into Moushuni Island. According to 2011 Census the total population of the Island is 22073. The island consists of four villages, such as **Baliara, Bagdanga, Kusumtala and Mousuni**. 2011 Census shows that Baliara has a population of 8672, Bagdanga 4160, Kusumtala 5663 and Mousuni 3578. Of these erosional problem is much active at Baliara and Kusumtala village. These two villages occupy 64.94 percent population of the total population of Mousuni Island. The western coast of Baliara and southern and western parts of Kusumtala are much affected by the engulfing water. People living near these parts are always in a state of panic due to constant threat of water intrusion and flood in the high tide situation. The rising sea level, continuous and rapid erosion of the coastline encourage the sinking of the island that have forced the inhabitants of the area to relocate further inland in this fragile island. From the obtained image of Landsat 2 MMS(1977), Landsat 5 TM (1989,1997,2007) and Google Earth Professional (2018) it is found that 24.51 percent area of the Mousuni Island has been lost from 1977 to 2018. Sea level rise is responsible for this aggression of erosional activity of Bay of Bengal. The North western and western parts of the Island are much affected as this portion is open to the angry wavy tidal actions of Bay of Bengal. The Eastern part is eroded less as this portion is not open to Bay of Bengal and it is surrounded by calm Pitt's creek. The percentage loss of area of Mousuni Island from 1977 to 1989 was 4.18 percent and it reached to maximum (9.73 percent) during the period of 1997-2007. According to Mousuni Gram Panchayet Office about 2,200 families have been displaced or affected severely by the rising sea in Mousuni. The household survey of Baliara and Kusumtala- the most affected villages of Mousuni Island reveals that 54.84 percent people have lost their lands and the percentage of people who lost their houses is 38.71 percent. The survey also reflects that the fishing activity has been affected much (40.38 percent) due to erosion and engulfing of water. As the sea is engulfing the Island the fishing fields have been changed and so fishing activity has been affected much.

Map 44 – US Army Map , Mahisani Island



Map 45-48 – Evolution of Mahisani Island

Plate 61– Mahisani Island / Moushuni Island beach , Baliara , 21°37'55.65"N 88°13'6.70"E aft the Amphan cyclone landfall Plate 62– Fishing is the major activities in the island.

Plate 63– Erosion is the major problem of the island coastline. Plate 64 - The cyclones create a havoc in the shoreline areas.

G.Chuksar

Chuksar, a seasonally settled outer estuarine island is situated in south also called as Haribhanga or Chuk Saheber Dwip. Reaks (1919) stated that Lower Long Sand, another tidal sand ridge of the outer estuary is characterized by formanature of incipient islands fairly regularly. Morphologically, Chuksar is very dynamic in nature. It was evolved and developed as 1.19 km During the next 32 years (in 2001) it migrated north by 2 km a 2009 Chuksar has remained 0.56 km because of strong wave action and its small size. One lagoon is found here in its western part. Marshy land found in middle part. The typical prevailing south-western waves of outer estuary (Evolution of Chuksar Bandyopadhyay et al., 2004). south-west of Sagar. It is 2 tiny island between 1942 and 1968 and gained2 area. The island is constantly changing its shape horn shape pointing north Chuksar: 1967-2012..

Map 49 – Chuksar island

Landform Characteristics of the Island areas and Classification

Broadly, the landforms of the islands may be classified as the **coast** and **island** interior. These are further subdivided into seven genetic morpho types on the basis of their formation, location and landform found therein. These are: Beach, dune, beach-bank transitional, river bank, inter distributary estuarine swamp, intra-island creek and swamp and inter-creek reclamation.

a. Beaches: The littoral environment at the junction of the land and the sea is sometimes found in the form of an accumulation of unconsolidated materials, lying between the lowest level of spring tides and the highest level reached by storm waves: are known as beaches. At present, the central section of the Sagar beach (Gangasagar-Raspur) is stable or accreting while the western (Beguyakhali) and eastern (Basantapur-Shibpur) sectors are being subjected to moderate to severe erosion. Coastal long sandy beaches are also found at **Jambu** and **Chuksar** islands and are accreting in nature. Ripples, rills, bioturbation structures and mud balls are found here.

Plate 65– Gangasagar Beach, 21°38'3.66"N, 88° 5'3.88"E

Plate 66 – Ripples in Gangasagar Beach

Plate 67 –Bakkhali Beach 21°33'47.40"N 88°15'35.19"E

b. Dunes: Coastal dunes are found in Sagar and Chuksar island areas. In Sagar, these are confined mainly to the zone east of the Gangasagar creek in the central and western sectors of the southern coastline. Beside these, low and isolated dunes over supratidal sand platforms also occur in the south-western and south-eastern transitional zones.

c. Beach-bank Transitional: This is characterised by association of both the marine and fluvial landforms.

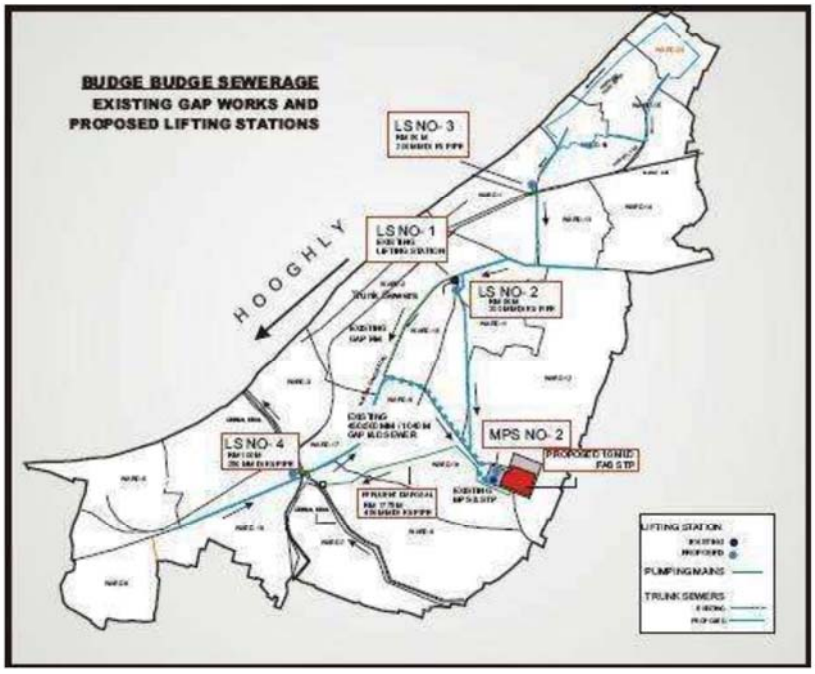
d. River Bank: In case of Sagar, eastern and western coasts are classified as river bank. Nayachar and Ghoramara have river banks surrounding the islands. Mudflats are common feature found here. These are tracts of low-lying shoreline submerged at high tide and composed of silt or clay to varying depths. It often forms behind a bar or spit and is carved into channels by tidal ebb and flow. The mud is deposited by flocculation. In Sagar, the eastern and western coasts of the island, classified as river bank areas and are characterized by wide to narrow tidal mudflats. This intertidal stretch in north-eastern and north-western banks is narrow and devoid of any vegetation, whereas in the south-east and south-western parts, it is 0.5 to 1.5 km wide and colonized by strandline grasses and herbs like *Porteresia coarctata*, *Salicornia brachiata* etc. In Ghoramara, tidal mudflats are common feature along riverine areas.

Plate 68 – Tidal Mudflats , Ghoramara.

4.4. THE CANAL SYSTEM OF THE STUDY AREA - The drainage of low-lying areas is a question of considerable importance in the 24 Parganas in the country to the south of Tolly" s Nullah, where largo tracts so swampy and water - logged that artificial drainage is necessary to make them cultivable. According to the Bengal Gazeteer of 1887 , By far the most important drainage scheme as yet instituted in tho district is the Magra Hat scheme, which provides for the Diamond Harbour and Magra Hat by moans of a system of channels, with controlling sluices, which are designed to serve both as drainage and navigation channels. The country benefited by the scheme forms part of a large area, which is surrounded by a continuous embankment, known as the 24-Parganas embankment and in part as the Hugli left embankment. Starting just below Akra on the left bank of the Hugli river, it forms the left flanking embankment of that river for some 78 miles, as far south as Ohitamari, where it turns towards the east and then to the north-east, forming a. Protection to the country from the large tidal creeks of the Sundarbans.. The whole enclosed area is about 717 square miles, of which the tract affected by the Magra Hat scheme occupies mainly the eastern and central portions. A striking feature of the enclosed tract is its uniformity of level .There is no general "trend" of the ground in any direction, except locally, so that the drainage as a rule follows the direction of what are, for the time being, the most efficient outfalls. The embankment is pierced by numerous open khal, which serve as exit-channels for rainwater. Until the execution of the drainage scheme, only some of these channels had sluices; in the other channels protection was afforded by " returning " the embankment along their flanks. The most important of the sluices in question are as follows :

a. The 5-vent **Charial Khal** sluice at Budge-Budge– **(22°28'44.92"N / 88°10'13.58"E)** Sewerage area covered under the Churial Canal is 164.989 sq.km (63.70 sq. mile) out of which 141 sq. km (54 sq. mile) is within CMC and 23.33 sq. km (9.01 sq. mile) of areas lies Budge Budge. Main canal having length of 17.59 km, passes through Behala to East Barisha and finally meets Hugli river, through five points sluice with capacity of 28.32 cumec (1000 eusec) under BudgeBudge Municipality. Another Khal of 7.01 km is length, flows from Mithapukur through Pujali and meets Hugli river through 56.33 cumec (1989 cumec) sluice, covering the area from Motilal Gupta Road to the east of Barisha. Churial Khal is 1.99 km in length, together with 15 branch Khal and 20 sub branch covering a total area of 50.32 km.

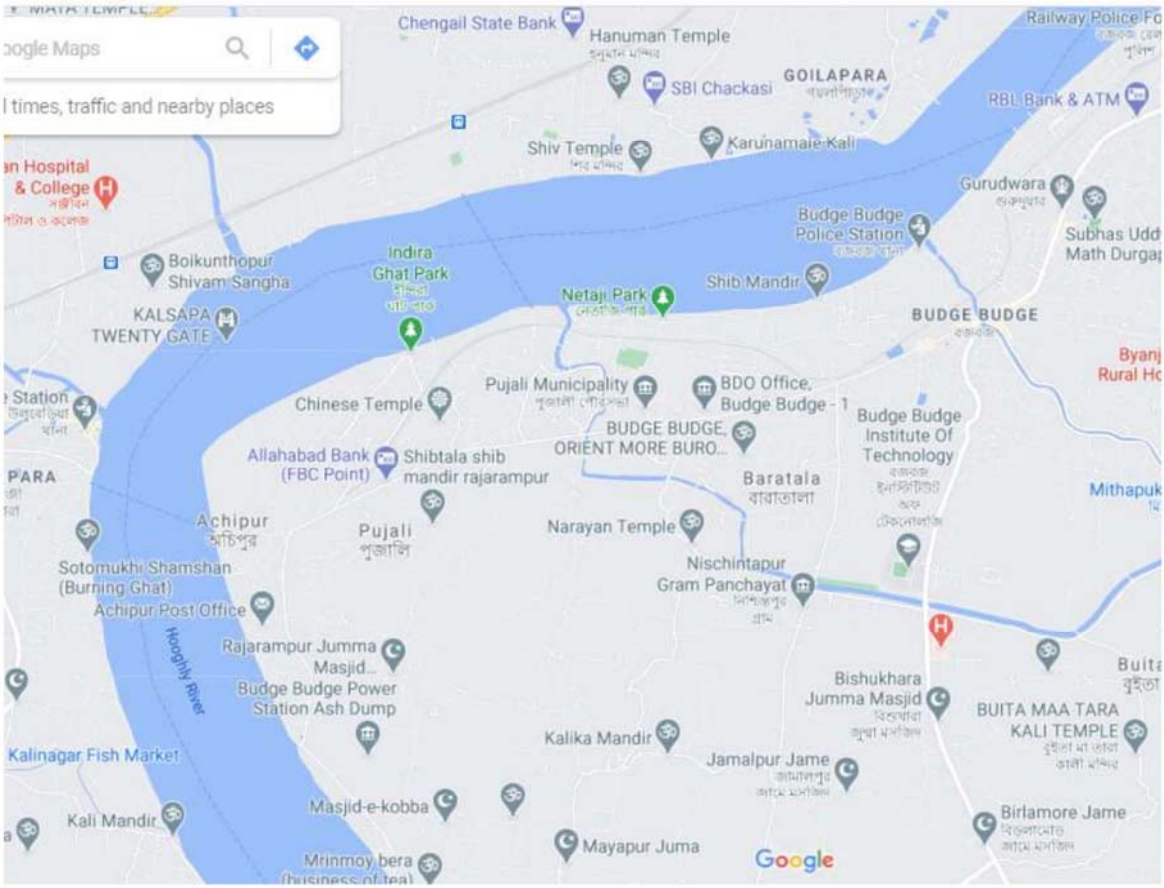
These khals discharge sewage of Budge Budge, Bishnupur, Mahestala and the areas under Thakurpukur police station, parts of borough XHI and borough XIV are also served by Churial basin. Considerable portions of Wards 122 and 123 in borough XIII and the area lying to the south of Biren Roy Road (west) and a certain portion of ward 127 in borough XIV (covering Wards 124 to 126 and part of 127) gets drained to Churial canal aided by its tributaries namely Churial Canal extension, Kalagachia Canal and Suti Canal. The drainage system within this area is grossly inadequate and mostly occur through open drainage network. Moreover, substantial length of the exiting drains is of unlined section. Besides storm runoff, all the drains cater sewage water as well. No underground drainage system persists within this basin. South Suburban East STP constructed under GAP Scheme to treat dry weather flow generated from Tolly's Nullah basin is located within this basin. As already discussed, although the GAP sewers are designed to cater DWF only, but in reality those are catering SWF as well. As a result, a considerable quantity of SWF is also reaching to the STP. It has been observed that the outlet system from the STP is not fully developed and due to lack of adequate disposal arrangement of the storm water flow catered by the GAP system, the flood situation in Ward 124 has aggravated. Southern portion of this basin is predominantly rural in nature, low lying and devoid of organized drainage system. It has been observed that flooding situation in this area persist for months together.



Map 50 – Sewer Line , Budge Budge

Plate 69– Churial Khal Outfall , Budge Budge 22°28'44.20"N 88°10'14.04"E

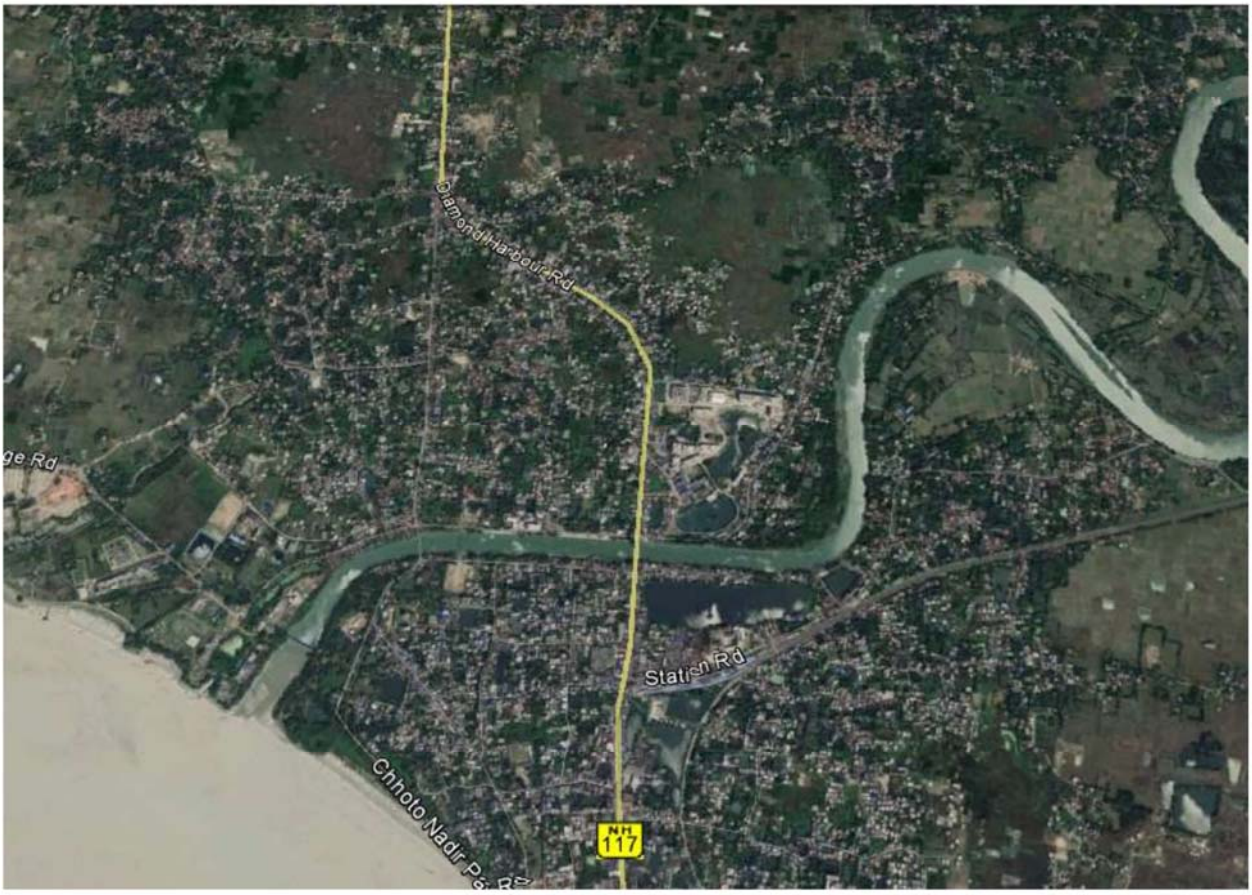
Plate 70– Churial Khal Lock Gate , 22°28'41.02"N 88°10'17.17"E



Map 51 & 52 –Churial khal , High resolution Image, Map

B. Diamond Harbour canal- 22°11'31.37"N/ 88°10'49.38"E

The main sluice at Diamond Harbour is designed to discharge the drainage from an area of 215sq.mile draining the whole of the areas drained by the Kaorapukur Khal, the tracts lying around Hotar, Nainan Magra Hat, and Surjipur, which used to find an outlet through the Surjipur Khal ; the whole of the tract oonnected with the siltedup Sangrampur Khal, as well as the area lying to the north of the railway between Magra Hat and the Nazra Khal; the country to the north, ·which is drained by the Srichandra Khal and the great .Jaynagar swamp.



Map 53 & 54 - Diamond Harbour Canal

Plate 71– Diamond Harbour Canal , 22°11'43.69"N 88°11'19.69"E

Plate 72– Diamond Harbour canal Outfall , 22°11'29.19"N 88°10'49.62"E

C. Kulpee Canal - 22° 5'7.51"N/ 88°13'36.07"E

Amidst the brick kilns along the Baruipur Kulpee Road is the Kulpee Canal which is also an important outlet of Magra Hat drainage scheme.

Map 55 – Kulpee Canal

D. The creeks of Sagar Island - The island has an area of about 300 sq km and is criss-crossed by twelve large and small tidal creeks strewn with mangrove vegetation, all connected with the principal estuarine water bodies, either on the east or on the west coast. **Chemaguri creek** is the principal creek in this island with flourishing mangrove vegetation at the bank. The island has an old light house on the south-west corner which offers settlement of a variety of bivalve and gastropod species.

Map 56- Sagar Island (administrative map)

Table showing some of the Major Creeks of the Island –

Sl no	Name of the Creeks	Origin	Offtake
1.	**Muriganga Creek**	Bamankhali 21°49'18.10"N 88° 7'16.60"E	N. Eastern part of the Island near Sikharpur 21°48'52.85"N 88°10'8.85"E
2.	**Chemaguri Khal**	Fuldubi 21°47'8.04"N 88° 6'41.29"E	S. Eastern part of the Island Bankimnagar 21°40'57.15"N 88° 9'8.63"E
3.	**Boatkhali**	Narayaniabad 21°40'27.15"N 88° 5'14.99"E	South East, Bishalakhsmipur 21°38'15.40"N 88° 8'20.58"E
4.	**GangaSagar Creek**	Near Narayaniabad 21°40'7.25"N 88° 4'57.05"E	South , Near Kapil Muni Ashram 21°37'59.66"N 88° 5'14.30"E
5.	**Beguakhali Creek**	21°39'39.54"N 88° 3'26.21"E	South West near Light House 21°39'3.86"N 88° 2'55.50"E
6.	**Naraharipur Creek**	21°45'14.25"N 88° 5'3.53"E	21°43'58.70"N 88° 3'49.51"E
7	**Mandirtala Creek**	21°47'13.99"N 88° 6'38.95"E	North West near Mandirtala 21°47'5.37"N 88° 4'53.13"E

Plate 73– Ganga Sagar Creek 21°38'16.02"N 88° 5'18.26"E

Plate 74 - Muriganga Creek , 21°48'53.42"N 88°10'9.54"E

Plate 75– Sikarpur Khal Mouth 21°48'35.75"N 88°10'10.89"E

Plate 76– Boatkhali Khal in Shibpur Mouza , 21°38'13.81"N, 21°38'13.81"N

Plate 77- Boatkhali Khal opening up in Bay of Bengal 21°38'13.81"N 88° 8'19.74"E

Map 57 - a. Chemaguri Creek - 21°39'5.26"N, 88° 3'1.46"E (opening up in Muri Ganga)

Plate 77 - Chemaguri Creek , with Benuban Jetty (Ferry Service Connecting Namkhana)

21°40'45.39"N 88° 8'55.02"E

Plate 78 – Kochuberia Khal , Offtake Point 21°51'34.54"N 88° 8'37.58"E

Plate 79– Kochuberia Khal with Fishing Trawlers, 21°51'34.43"N , 88° 8'34.54"E

Map 59 - Muri Ganga Off Take - 21°48'52.43"N/ 88° 9'58.88"E

Plate80 – Muri Ganga Creek,
21°48'53.09"N 88°10'9.92"E

Map 60 - Mandirtala Creek, 21°47'4.94"N 88° 4'50.15"E opening at Hooghly River

Map 61 - Mayagoalini Ghat , Naraharipur, 21°43'59.21"N 88° 3'48.44"E, opening at Hugli River

Plate 81- Gangasagar Creek , 21°38'2.22"N 88° 5'15.12"E

Plate 82- Kapil Muni Temple , Ganga Sagar , 21°38'22.94"N 88° 4'47.23"E

Plate 83 – Beguakhali Creek 21°39'5.97"N 88° 2'57.07"E

Plate 84 – Beguakhali Creek 21°41'16.40"N 88° 3'4.91"E

Plate 85 – Mayagoalini Khal , 21°47'1.68"N 88° 4'55.03"E, Plate 86- Chemaguri Khal

CHAPTER 5 – DOCUMENTING STRUCTURES INTHE RIVER

5.1. GHATS IN THE STUDY AREA –Hugli River in South 24 Parganas has comparatively less number of Ghats than that of the Adi Ganga which moves out through Joynagar , Majilpur, Chatrabhog and ultimately joins with Bay of Bengal through Bartala Creek or Saptamukhi Creek.

Our study area includes –Thakurpukur , Budge Budge I & II Block , Falta, Kulpee, Diamond Harbour I & II Block, Kakdwip , Sagar , Namkhana . Thukurpukur, Budge Budge , Falta, Kulpee are heavily industrialised and from Kakdwip onwards the characteristics of the buffer area is completely different . River becomes very wide after receiving Rupnarayan River and Damodar River near Falta at HugliPoint . Domestic usage is rare . Jetties and harbours (fishing harbours) are more found. There are innumerable brick Kilns along the river.

The List of Ghats and Jetties are as follows-

Sl.no	Ghats	Location
1.	Santoshpur Ferry Ghat	22°31'43.80"N 88°14'47.25"E
2.	Akra Ferry Ghat	**22°31'33.65"N** **88°14'42.00"E**
3.	Batanagar Ferry Ghat	22°30'53.03"N 88°12'46.14"E
4.	Budge Budge Ghat	22°29'42.13"N 88°11'17.05"E
5	Jhautala Ghat	22°28'59.23"N 88°10'27.75"E
6	Pujali Ghat	22°28'28.59"N 88° 8'37.85"E
7.	Achipur Ghat	22°28'10.85"N 88° 7'42.82"E
8.	Birlapur Ghat	22°25'14.44"N 88° 8'51.25"E
9.	Raipur	22°23'56.98"N 88° 8'23.00"E
10.	Burul	22°21'44.80"N 88° 6'16.38"E
11.	Boragachi-kantakhali Ferry Ghat	22°19'47.43"N 88° 6'8.78"E
12.	Falta Ferry Ghat	22°18'5.34"N 88° 6'19.69"E
13.	Falta Jetty	22°15'16.74"N 88° 5'18.49"E
14.	Noorpur Ghat	22°13'32.45"N 88° 4'41.42"E
15.	Noorpur Ferry Ghat	22°12'39.46"N

		88° 4'17.72"E
16	Bhabanipur Ghat	22°12'34.64"N 88° 6'4.23"E
17.	Raichak Ferry Ghat	22°12'27.38"N 88° 7'9.54"E
18.	Raichak Ganga Kutir	22°12'21.85"N 88° 7'23.86"E
19.	Diamond Harbour Ghat	22°11'30.38"N 88°10'50.73"E
20.	Diamond Harbour Jetty	22°11'1.02"N 88°11'24.26"E
21.	Sultanpur Fishing Jetty	22°10'11.58"N 88°12'2.82"E
22	8 No. Lot	21°53'26.55"N 88° 9'56.04"E
23.	8. No. Lot Jetty	21°52'51.34"N 88° 9'50.95"E

MAP 60 - 8 No. Lot , Kakdwip, Gateway to Sagar Dwip, Last point of Main Land

Plate 87 – 8 No. Lot Ghat , Kakdwip 21°53'26.95"N 88° 9'56.82"E

Plate 88– Kachuberia Jetty, 21°51'32.13"N 88° 8'41.80"E

Map 61 - Kachuberia Ferry Ghat , Sagar

Map 62 - Hooghly Point , Confluence of Rupnarayan and Hooghly River

5.2. INLAND NAVIGATION

5.2.A. National Waterway -1

Ganga-Bhagirathi-Hugli river system from Allahabad to Sagar was declared as NW-1 vide. National Waterways Act 1982 (49 of 1982). It became operative from 27th October 1986. The map of the NW-1 is given in Fig. 1. Only a part of this waterway (Sagar to Farakka; about 560 km total length of NW-1 1620 km) is intended to be used for the proposed coal transportation . TheHugliriver portion of the waterways from Sagar to Nabadwip is a tidal stretch. The vessels coming through sea navigate up to Kolkata (140 Km) and the fair way up to Kolkata is maintained by the Kolkata Port Trust. From Kolkata to Triveni, there is no restriction for navigation by inland vessels of a loaded draft up to 4 m. From Nabadwip to Jangipur the waterway is formed by Bhagirathi river, which is a regulated river from the Barrages at Farakka and Jangipur. With the controlled discharge from Farakka Barrage and limited river conservancy work, a navigable depth of 2.5 m is maintained by IWAI in this route throughout the year (Source : IWAI) .

Map63-National Waterway No 1

5.2.B. Ferry Services- River Bhagirathi- Hugli still plays a very important role in transportation of people and cargo to move to the opposite bank of the river easily. Through Ferry Services , South 24 Parganas is connected with Purba Medinipur and Haora District . Here is a list of Ferry Service facilities in our study area.

1. Budge Budge Ferry Ghat - Swami Vivekananda landed at Budge Budge ferry ghat in 1897 when he returned from his Chicago visit. The anniversary is still celebrated on 19 February with great zeal. From Budge Budge Ferry Ghat , ferry service is available for **Bauria (Haora)** .

Plate 89– Budge Budge Ferry Ghat 22°30'53.39"N 88°12'45.68"E

3. Achipur Ferry Ghat - Achipur, a hamlet on the banks of the Hugli, is just like any other Bengal village. But 300 years ago, this village, 30 km from Taratala, bustled with activity and was dominated by the Chinese people . This was the first Chinese settlement in the country. Ferry Service Connects Achipur,Pujali to Uluberia of Haora District.

Plate 90– Achipur in Budge Budge II Block having Ferry Service connecting Uluberia , Haora.

Plate 91 – Akra Ferry Ghat commuting people to Manickpur , Haora .

4.Batanagar Ferry Service - Batanagar was established to start the first shoe factory in India by Czechoslovak industrialist Tomáš Baťa. It is one of the places named after the multinational shoe company Bata. There is a plant of the Bata company here. The employees mostly reside in Batanagar.

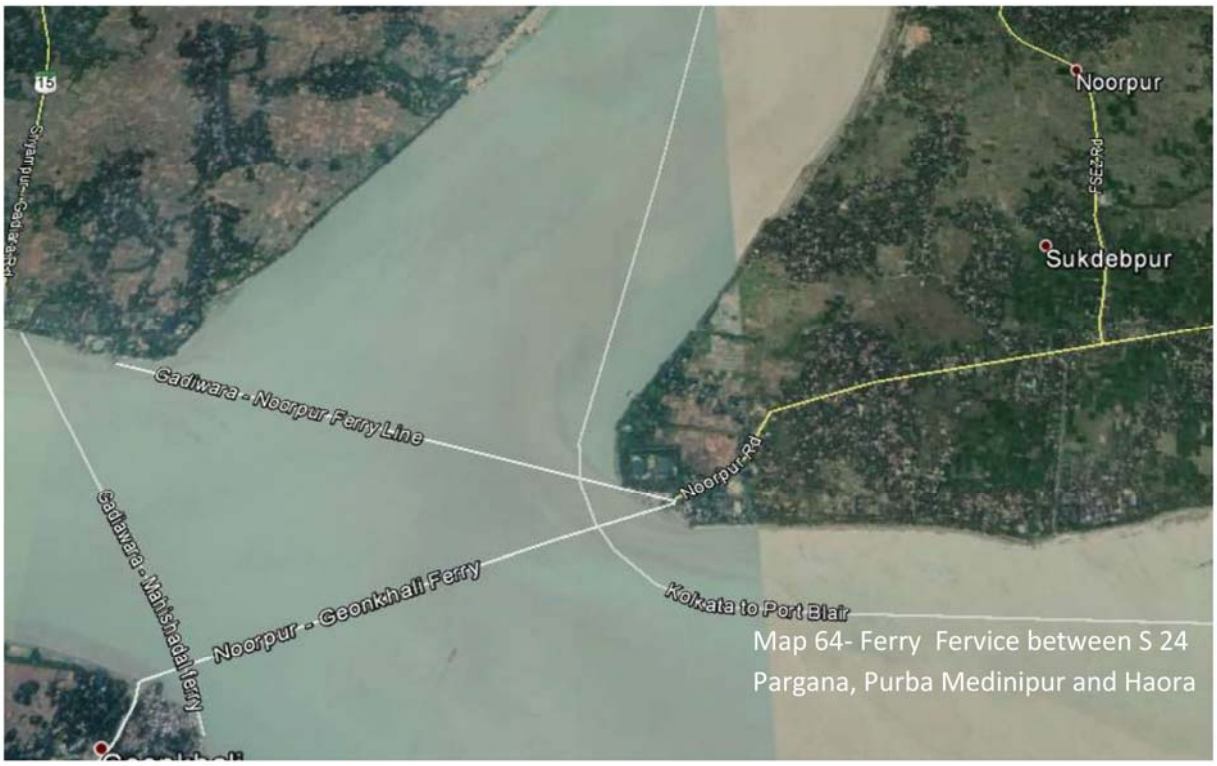
Batanagar is well connected through Ferry Service. Regular ferry plies to Hirapur Ghat , and Sarenga of Haora district.

Bust of Thomas J. Bata, son of Tomáš Baťa, at Batanagar Sports Club

Plate 92– Batanagar or Nungi Ferry Service connects South 24 Parganas with Sarenga Ferry Terminal , and Hirapur Ghat in Haora District. 22°30'50.46"N 88°12'44.15"E

5.Noorpur Ferry Service- Noorpur along Bhagirathi Hugli is also said to be as the Hugli Point .Regular Ferry services are there connecting Noorpur to Gadiara (Haora) and Geonkhali (Purba Medinipur).

Plate 93: Hugli Point , 22°12'41.91"N 88° 4'13.76"E , South 24 Parganas



Map 64- Ferry Fervice between S 24 Pargana, Purba Medinipur and Haora

Plate94 – Noorpur Ghat where passengers are coming from Geonkhali , Purba Medinipur

Plate 95– Noorpur Jetty , 22°12'38.91"N 88° 4'20.02"E, South 24 Parganas

6.Raichak Ferry Service – Raichak in Diamond Harbour Block is connected with Purba Medinipur through Raichak-Kukrahati Ferry Service. The ferry service is available every 30 minutes from 6-00 am on both sides to 8-00 pm at Kukrahati and 8-40 pm at Raichak.

Plate 96 ; Raichak on the Bank of River Hugli

7. Diamond Harbour - The British renamed a settlement called Hajipur as Diamond Harbour. It no longer has a harbour, but there are a few bricks to designate the location of an old fort. It used to be a safe resting spot for ships and even today offers a spectacular view of the river. Prior to the British, Portuguese pirates had a major influence in the region. The ruins of the fort of Chingrikhali (locally known as Purano Kella) cannot be seen any more. It is uncertain whether the fort was built by the Portuguese or the British. There used to be an old lighthouse, which has now been eroded by the river. This small town with a picturesque setting is the gateway to the south-western part of the district, leading to such places as Gangasagar, Kakdwip, Namkhana and Bakkhali. Jetties at Diamond Harbour, Raichak and Mirpur provide steamer services to the other bank of the wide river estuary

Plate 97 &98– Diamond Harbour Jetty , 22°11'6.07"N 88°11'21.25"E . Provides Ferry Service to Kukrahatti , Purba Medinipur .

8.Kakdwip - Kakdwip is a city of the South 24 Parganas district in the Indian state of West Bengal. It is situated on the eastern banks of theHugliRiver. It is the headquarters of the Kakdwip subdivision and Sundarban police district. When the Tebhaga movement broke out in 1946, the peasant movement affected several areas of what is now South 24 Parganas. Kakdwip and Namkhana were the storm centres of the movement. Kakdwip fishing port is located at Kakdwip in south twenty-four Parganas in the coastal district of West Bengal, India. It is an important full-fledged fishing port. The port is developed in the left-front period. Every coastal area and deep seas in this port from the fish trawler anchor.

9.Hard Wood Point Jetty (8 No. Lot Jetty) in Kakdwip - Trawlers, ferries and old boats, with a constant stream of people who live on the islands in the Sunderbans — the Hardwood Point jetty is a glimpse into another side of Kolkata. Harwood Point, or Lot 8, is the jetty where people take a ferry to Ganga Sagar or Sagardwip, and to Ghoramara — two islands on the Sunderbans delta in the Bay of Bengal.

Plate 99– Kakdwip Hardwood Point Jetty , connecting Sagar & Ghoramara Island

10.Namkhana Jetty - Namkhana is a village and a gram panchayat within the jurisdiction of the Namkhana police station in the Namkhana CD block in the Kakdwip subdivision of the South 24 Parganas district in the Indian state of West Bengal. Namkhana Jetty on Hatania Doani River connects Benuban Jetty , Sagar Island and Bakkhali .

Plate 100- Namkhana Jetty , 21°45'39.71"N 88°14'9.85"E

11. Kochuberia Jetty - Sagar Island is about 80 km south of Kolkata, cut off from the main land by Muriganga river. At present there is no road bridge to connect the island to the main land. The Muriganga river can be crossed by ferry service to reach the Sagar Island. After crossing, the confluence of Sagar (bay of Bengal) & Ganga (holy river Ganges) can be reached via private taxis also which generally charges around INR 700 and it takes about 40 minutes to reach the confluence area from Kachuberia. To reach Sagar Island one must cross the Muriganga river/creek by ferry service to reach 'Kachuberia jetty' on the Sagar Island. Ferry service is available in both Harwood point and Namkhana and controlled by West Bengal Surface Transport Corporation. Frequency of crossings are more in Harwood point and it is once in every half an hour. The fare for a single crossing for a person is Rs. 8 as in

16 March 2013. The fare increases at the time of Ganagasagar Mela (The Fair; Rs. 40,- during 2008 Mela).

Plate 101 &102– Kachuberia Jetty in Sagar Island , 21°51'29.02"N 88° 8'37.14"E

11. MayaGoalini Jetty – Located in the western side of Sagar Island is Maya Goalini Ghat which connects the island with that of PetuaGhat of Purba Medinipur District. The journey takes 2 and half hours to cross the wide estuary of Hugli River.

Plate 103 – Maya Goalini Ghat , 21°47'2.40"N 88° 4'53.04"E

Plate104 – Connection between Purba Medinipur and South 24 Parganas

11. Bagdanga Ferry Service – Connecting Namkhana with that of Moushuni Island crossing Chinai River , is the Bagdanga – Huzzati Ghat Ferry Service.

Plate 105 – Hujjati Ghat21°38'32.16"N 88°14'11.34"E Plate 106 - Bagdanga Ferry Ghat 21°38'33.62"N 88°13'52.18"E

5.3. HARBOURS OF THE STUDY AREA – A **harbour** (synonyms: **wharves**, **haven**) is a sheltered body of water where ships, boats, and barges can be docked. The term *harbor* is often used interchangeably with *port*, which is a man-made facility built for loading and unloading vessels and dropping off and picking up passengers.

A. Diamond Harbour – Earlier known as Hajipur , Diamond Harbour is a point from where the river moves towards south to Bay of Bengal. It is the city and a municipality of the South 24 Parganas district in the Indian state of West Bengal. It is situated on the eastern banks of the Hugli River. It is the headquarters of the Diamond Harbour subdivision and Diamond Harbour police district.

Plate 107a – Typical view of Diamond Harbour with ships moving towards Haldia or Kolkata Port.

Plate 107b – The largest fish collection centre is in Diamond Harbour . From this unit , fish gets distributed to the different fish markets of Bengal and also outside Bengal.

B.Kakdwip Fishing Port - Kakdwip fishing port is located at Kakdwip in south twenty-four Parganas in the coastal district of West Bengal, India. It is an important full-fledged fishing port. The port is developed in the left-front period. Every coastal area and deep seas in this port from the fish trawler anchor. The Kakadipu fishing port is actually a place where fishing boats or trawlers are anchored in a non-organized manner for loading, unloading and repairing and shelter. This place has long-term demand for fishing in fish fishing as well as for organizing fishing business at the same time. Department of Fisheries, Government of West Bengal, establishes the modern fishing port, which provides 50% of the cost to the Indian government and 50% of the state government. Minister Kiranmoya hoped for the success of the port of Nanda. Briath Barn Construction Limited (a government in India inaugurated the Calcutta) was the contractor for the project. Expert for the fishing support project in West Bengal, a consultancy firm, Associate and Associate, a project company in West Bengal. Chief person Gautam Banerjee, Principal Architect for Project Planning and Design The project is composed of RCT jetty built under 650 mm thick diaphrram wall. This method is applied to a wall of the jetty area and it was first introduced in West Bengal, for the first time in India.

Plate 108- Kakdwip Fishing Harbour

C. Namkhana Fishing Harbour- The active delta of southern W. Bengal occupy a number of estuaries mainly by the rivers Hugli, Saptamukhi, Thakuran, Matla, Gosaba, Harinbhanga and others. This huge estuary, a unique ecosystem, is one ofthe most productive zone ofthe country.! It comprises an area of2340 sq. km. where the fish production amounts to 22000 ton from the estuarine water and 20000 ton from the inshore water (on an average basis) with an annual fish landing of 94 kg/hec/yr. Different types of fishing gears are operated in it when bulk (70- 80%) ofthe fish landings are contributed by the winter migratory bagnet. The prime fish, Hilsa ilisha constitutes 8-10% ofthe total catch (1200-2000 ton/yr). Considerable changes, especially in the salinity pattern of the mentioned system, have been observed after the increased freshwater flow in it from the Farakka Barrage (1975). The yields of purely salinewater fish have markedly decreased.

Namkhana Fish Landing Centre (NFLC) - The study on estuary fishing had been done at Namkhana, 105 km. away from the city ofCalcutta, where the following facilities were available; Fish landing centre having ajetty for unloading the catch and loading ice-blocks, fuel, drinking water, food-grain; huge number ofworkers for loading and unloading, fish-

traders and vehicles to carry the catch to the market at Howrah or Calcutta. A charge is taken from the Office of Panchayet at Namkhana for loading/unloading. The following table shows the amount of unloading of fish at Namkhana fish Landing Centre (NFLC). At Namkhana, a wireless telegraph station is functioning to establish communication with the boats in the sea. Since the year 1979, Matsya Bichitra Marine Fisheries Training Centre has given the training programmes on-fitting and repairing of marine engine, constructing boat and navigation. This Centre has the arrangement to supply drinking water and ice and also financial assistance to the fishermen. From the office of NFLC the days of unloading fish have been collected by the method

Plate 109– Namkhana Fish Landing Centre , along Hatania Doani River , 21°45'39.27"N 88°14'12.61"E

CHAPTER 6 - DOCUMENTING LIVLELIHOOD PATTERN & ACTIVITIES IN AND AROUND THE RIVER HUGLI.

6.1. LANDUSE LANDCOVER STUDY IN THE STUDY AREA

The study area of South 24 Parganas District, is situated in the proper delta of lower Ganga plain. It is little higher above the flood level and the physical features are similar to deltaic land of the country.

On economic and geographical consideration the district may be divided into two parts - North and South. The northern inland tract is fairly well raised delta and more urbanized than the south. The southern portion is a low lying Sundarbans towards the seaboard. The Sundarbans are a unique network of tidal channels, river creeks and islands. There are some swampy marshes covered with low forest and scrub wood. The people of the environmentally diversified district practise a wide range of land-based economic activities that are mostly primary in nature.

Agriculture and fishing comprise the most important economic activities in rural landscape. Forest based livelihood activities are seen in the Sundarbans area including initiation of eco-tourism. While most of the factory establishments and activities of urban landscape are located in the north, the south is predominantly agricultural with other primary activities of rural landscape. Agriculture forms the backbone of the district but irrigation is a great hindrance in the district because main source of water for agriculture is monsoonal rainfall and supply of sweet water in few portions in northern area. Southern part suffers a lot due to pronounce presence of saline water in estuarine tidal rivers and creeks which sometimes creates havoc through ingression of brackish water lets the land unsuitable at least next three to four years. There is prominent diversity in cropping pattern between stable delta and active delta. Mono crop pattern of agriculture is still in practice in the region due to non availability of irrigation waters. Lack of waters for irrigation causes crop failure and reduction of area under multiple cropping. As regard crop diversification it has been observed that the southern part is comparatively less diversified than the north-western part because of the variation in favorable environmental condition (climate, soil, socioeconomic). It may further be pointed out that in the northern part; the land is used for other purposes. As a result, its share to agriculture and diversification in the cropping pattern decreases. Paddy, the dominant food crop, is grown in association with a variety of other crops, vegetables and fruits. The practise of mono-cropping occupies maximum agricultural land with only a negligible portion under

the second crop. In the southern saline tack, paddy is cultivated mainly in the monsoon season known as 'aus' rice but summer and winter varieties, i.e. 'aman' and 'boro' cultivation is done in the northern part of the district. Double-cropping is very important in agricultural area adjacent to the Kolkata urban area in fertile land in stable delta for supplying the vegetables to the city. The mangroves, estuarine char, mud land and tidal creeks in island region are clearly depicted A general landuse and cropping pattern map is prepared with the help of Landsat FCC Image , 2019 shows spatial distribution of Mono Crop Land , Double Crop Land , Settlement Areas , Waterbody , Mangroves , Other Vegetation and Mud flat . The major crop is rice, while the minor crop is pulse and vegetables growing areas in the district including rural-urban settlements, forest, orchard and plantation. Swamp area which is presently used as commercial fish production is also delineated in the map.

Plate 110– Paddy is the major agricultural crop of the study area.

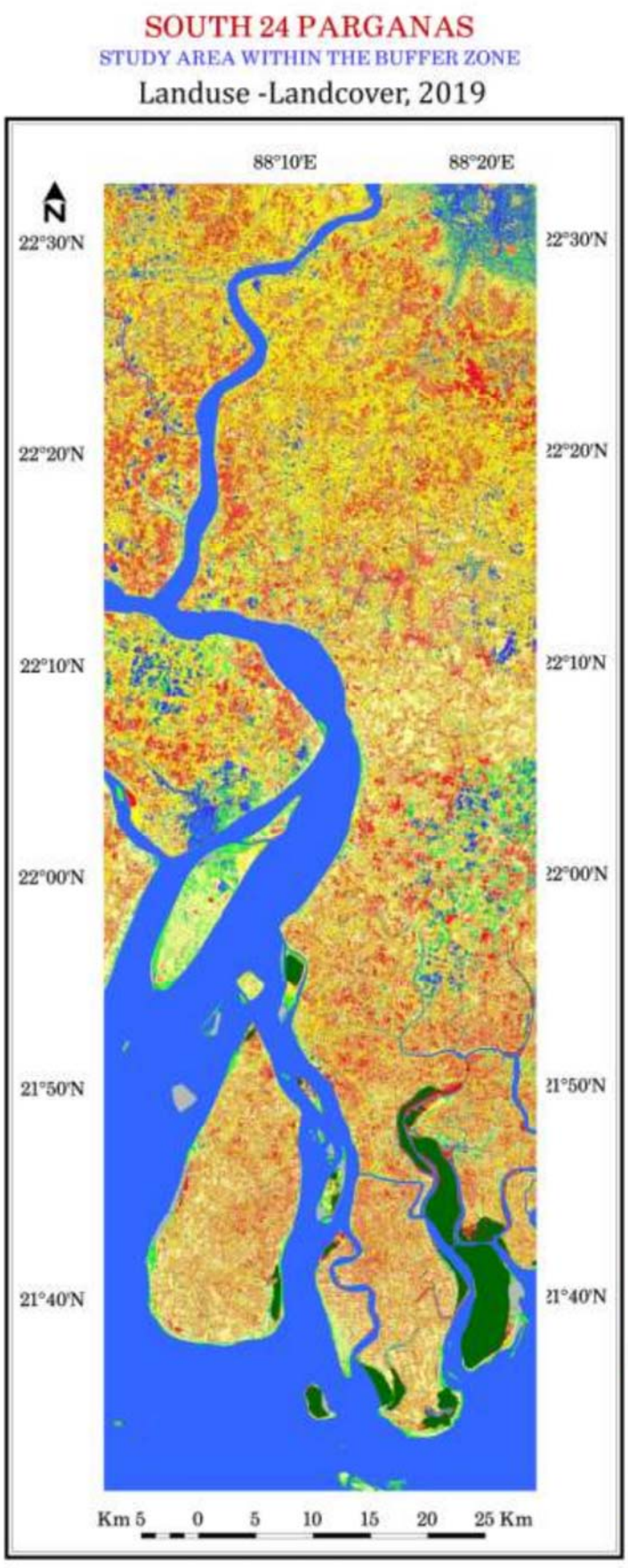
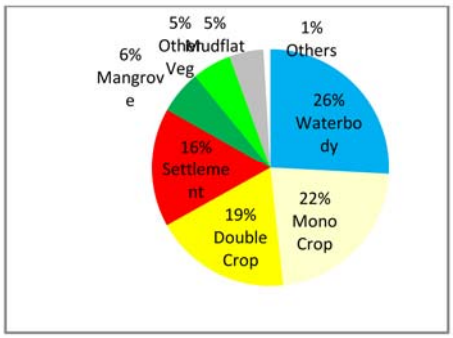


Plate 111– Sunflower Plantation , Namkhana , Plate 112- Aman Paddy , Sagar



Pie Chart showing the percentage of areas under different LULC

Map 66– Landuse Landcover Map of the Study Area based on 2019 , Landsat Image (FCC)

Plate 113 – Mangrove in Sikarpur Char 21°48'5.05"N 88° 9'58.50"E

Plate 114 – Waterbodies are used for aquaculture and paddy cultivation

Plate 115 – Mud Flat in the Eastern Part of the Island , 21°46'19.37"N 88°10'10.57"E

Plate 116– Sandflat in the Shibpur Boatkhali area , 21°37'59.69"N 88° 7'3.21"E

6.2. River / Channel bank using for various Economic activities

6.2A. Agriculture

Blockwise if we study the Landuse Landcover Classes we will find that the Southern Block like Sagar, Namkhana & Kakdwip have more mono cropped area than that of the northern blocks like Diamond Harbour or Budge Budge . Bettlenut is a very important cash Crop of Sagar Block. More than paddy , farmers are more prone towards Bettlenut Plantation which has good return value. Sun flower plantation is also sporadically done in Namkhana , Kakdwip Block as a second crop. Vegetables like Bhindi, Cabbage, Yams , Pumpkins ,Brinjals and Chillies are also produced. Fruits like Date Palms have a special place in all the southern blocks. Namkhana , Kakdwip & Sagar . Mono-cropping agriculture, fishing, tiger prawn seed collection and manual labour were the major occupational pursuits as well as source of income. The economy of the Sagar Islands/Blocks remains primarily agriculture oriented with fishery and *meen collection* supplementing the income of the people. Aman paddy, chilli and some selected vegetables and fruits were grown in the area. Along with agriculture or agricultural related works the people to a large extent also depended on fishing and *meen* collection.

Bettle Vine Plantation -The betel leaf creeper called pan was grown up in garden known as baraj, cultivated by the people of Sagar Islands in a larger extent. However, betel-vine cultivation had expanded greatly. The land devoted to it was 200 hectares. There were around 4500 betel leaf cultivators who had around 6500 betel-vines which were exported mainly out side of this Sagar Islands, from which they earned an ample amount of money and it was considered as the main cash crop of the Sagar Islands. It is to be further mentioned that directly and indirectly a remarkable section of people depended on betel-vine for their livelihood.

Date Palm Plantation - They produces good amount of Date Sap or Khejur Ras, (Bengali: খেজুর রস, romanized: Khejur Rosh) It is sweet sap extracted from the Date Palm trees of the Bengal in winter. This is symbolic and synonymous of Bengal winters. This Date sap is famous food over the peoples of the rural as well as the urban of Bengal. It contains high natural sugars and others natural form. Numbers of others popular foods are also made from or using this Date sap like date Jaggery or Palm sugar, pitha etc. A date palm tree starts to produce sap from 5 years. Amount of date sap, sugar, quality etc. depend on the

soil, climate and type of date palm. Mainly the male date palm tree gives more date sap than the female tree. The sap of the male is also sweeter than the female.

Plate 117 :Beetle Vine Plantation, Sagar

Plate 118 - Paner Baraj – Beetle Vile Plantation Shed , Namkhana

Plate 119 - Gur preparation from Date Palm Juice, Namkhana

Plate 120 : Date Palm Sap Collection

Plate 121– Sunflower Plantation in Namkhana Block adjoining Hatania Doani River

Plate 122– Paddy Field , Namkhana

Chilli Cultivation - Chilli is now considered to be one of the important cash crop of this Zone and it is being exported to other areas. At present, Chilli covers more than 3 per cent of the total cultivable area of this District and the production is around 28,000 tonnes. Sagar, Namkhana, JKakdwip blocks have moderate concentration (3-4 per cent of T.C.A.) of area under chilli. In general, chilli is now being grown in almost all blocks of this District.
Water melon is another promising crop suitable for the saline sandy tracts of the southern part of the Study Area.

Jute : Jute is an important cash crop. It covers only about 0.5 per cent of TCA. It generally grows well on loamy soil. Some amount of jute is also grown in Budge Budge, Kulpi, Magrahat blocks. The jute mills in Budge Budge, Maheshtala and adjoining areas provide the main market for raw jute.

Oilseeds : Mustard is the principal variety of oilseed grown in this District. Recently sunflower, til (sesamum), groundnut, soyabean, linseed etc. are being cultivated due to expanding market of oil extracted from them. Special incentives are also being given to the farmers from the government for cultivating oilseeds. The loamy soil with medium salinity, as is found in the southern part of the District, is quite suitable for growing **sunflower.** Groundnut can also be grown on the coastal sandy soil. Improved varieties of seeds are being distributed from time to time for growing sunflower by the State Government. The result is quite encouraging.

Plate 123– Chilli Plantation , Kakdwip

Plate 124– Cabbage Cultivation , Sagar Island

Plate 125- Leafy Vegetables , Kakdwip

B. Aquaculture - Fishery (fishing and aquaculture) is treated as the backbone of Sundarban economy. Sundarban boasts around 172 species of fishes, 20 species of prawn and 44 species of crabs including two commercial species. This region is the top producer of fish and prawn, with both districts (South & North 24 Parganas) combined producing roughly 31% of the total inland fish/prawn production of West Bengal. Apart from coastal and brackishwater aquaculture, freshwater aquaculture is increasing steadily and contributes parallel economy and livelihood security in the region. Majority of surveyed farmers in two blocks are marginal and small-scale farmers having perennial fishponds and practise traditional farming. Brackishwater aquaculture is prevalent only in peripheral areas which are adjacent to river or creek and tide-fed. On the contrary, freshwater aquaculture is vast, wide spread and rain-fed. In freshwater, composite carp culture is popular, though in some cases farmers culture high value Scampi (Macrobrachium rosenbergii) with the carps. Farmers often culture tilapia (Oreochromis mossambicus and O. niloticus) in fresh and brackish water with other fish / prawn for better production. In brackishwater, farmers mostly culture tiger shrimp (Penaeus monodon) with the fishes like Lates calcerifer, Liza tade, Liza parsia, Mugil cephalus, Etroplus suratensis, Scatophagus argus etc. Survey results reveal that the fishponds in low-lying areas of Gangasagar, Dhablat, Ramkarchar, Daspara Sumati Nagar and Ghoramara Gram Panchayats of Sagar block are prone to coastal flooding during rainy seasons. It leads to breach of pond dyke, ingression of saline water into freshwater pond, escape of fish stock from the pond, entry of other (often unwanted) fish species, fish mortality etc.

Plate 126 - Tiger Prawn Farming , Sagar Island, 21°38'20.29"N 88° 3'45.49"E

Plate 127– Aquaculture Pond , Ganga Sagar , Jelepara 21°38'51.91"N 88° 3'5.44"E

Plate 128– Dry Fish farming in Sagar island , 21°38'51.91"N 88° 3'5.44"E

Fishing Industry - The unique location of South 24-Parganas District within the active deltaic zone of the Ganga Basin, which faces the Bay of Bengal to the southern part, is no doubt the most favourable factor for the development of fishing and related activities based on aquatic resources of this region. The District is not only criss-crossed by innumerable rivers, creeks, estuaries and cross - channels, but also dotted with numerous water bodies which may be used as the base of aquatic resource development. Above all, the dense mangrove forest in the south-eastern estuarine tract of the District, which is popularly known as the Sundarban provides an unique ecological niche for the propagation of a great varieties of palatable brackish water fishes like *Parse (Mugil parsia), Bhetki (Lates calcarifer), Bhangar (Mugil tade), Hilsa (Hilsa ilisha), Tangra (Mystus sp.), shrimps and prawns, and different types of shells and molluscs.* The total water area available for pisciculture in the District is about 32,000 hectares. This includes 828 ha of bheries, 262 ha of government assisted coastal fishing units, 634 ha of government assisted river units and 2,716 hectares of vested impounded water areas. Quite a sizeable population is either directly or indirectly dependent on fishing for their livelihood. Fishing plays an important role in the occupation structure of the rura people, particularly those living in the coastal and estuarine tracts. The number of fisherman families in the District is more than 66,000. However, in general, the socioeconomic condition of the fishing communities is very poor. Often they are victimised by natural hazards like cyclones, storm surges and tidal bores. Moreover, inadequate or lack of infrastructural facilities, like quick transport, marketing, refrigeration and other facilities are deterrants to the growth of commercial fishing in this area. Lack of knowledge about modern scientific fishing technique, poor organisation amongst the fishermen also stand in the way for the growth of fishing as an organised industry. Besides these, too much exploitation of fishermen by middle men and money-lenders, has made their economic conditions, more deplorable. However, in spite of all these handicaps, the vast water areas of the Study area have great potentiality for the development of fishing as a highly remunerative occupation. It is unfortunate to note that, out of about 400,000 ha of estuarine tract of the Ganga Delta, only 20,000 ha are being utilised for fisheries. The proximity of Calcutta is an added advantage, as this metropolis offers the largest inland market for fish in the country. Moreover, there is an ever increasing demand for shrimps, specially the Black tiger variety in foreign countries. Hence, since late 1980's more emphasis is being given by the planners on fishing for generation of rural employment, production of protein-rich food to raise the nutritional level, and at the same time to earn foreign exchange.

Types of Fishing On the basis of locational aspect, the fisheries of South 24- Parganas District may be broadly classified into the following categories: **I) Marine and offshore fisheries ii) Estuarine fisheries iii) Inland fisheries**

I. Offshore and Marine Fishing - In South 24-Parganas District, deep sea fishing or rather say fishing in the offshore zone of the Bay of Bengal still remains neglected in spite of potentials of this vast resource. Such offshore fishing is capital-intensive requiring additional infra-structural facilities. Sagar Island, Jambudwip, **Diamond Harbour**, Fraserganj, Namkhana are important collecting centres of marine fish.

Plate 129 - Fishing Trawlers , Hatania Doani , Namkhana , 21°45'48.12"N 88°13'54.48"E

Plate – Diamond Harbour , the biggest fish collection centre, Bhetki ,Pomfret fish are getting sorted in the collection centre.

Plate – Big fish (Rohu / Catla) are getting auctioned in the fish collection centre , Diamond Harbour

Plate – Hilsa , one of the major fish getting sorted in the Collection centre.

II. Estuarine Fishing - Potentiality of estuarine fishing is very high in this region due to the existence of mangrove forest. The litters of mangrove forest play an important positive role in the production of huge amount of fish food like phyto-plankton, zoo-plankton etc. which in turn attract great varieties of brackish water fishes. In the estuarine part of South 24-Parganas, particularly in Sundarban region, more than 120 euryhaline fish species are caught in commercial amount (Naskar, Guha Bakshi, 1982). Amongst these, Hilsa (*Hilsa ilisha*) is the most important and favourite. The next important are Bombay duck (*Harpodon nehereus*), Parse (*Mugil parsia*), Bhetki (*Lates calcarifer*), Cat-fishes etc. Tiger shrimp (*Penaeus mondon*), however, draws the attention of most fish traders for its high export potentiality. Varieties of crab belonging to different genera and species are available in Sundarban region. But amongst these the economically important edible ones are Scylla serrats (Forskaal) and Neptunus pelagicus (L). Various types of brackish water fishes like bhetki, parse, pomfret etc. have high demand in domestic market, while the tiger prawn is exclusively harvested for international market. Brackish water fish farming is mainly practised extensively in the southern and eastern parts of this District over an area of about 2,500 ha covering large areas of Gosaba, Basanti, Canning, Kultali, Kakdwip, Namkhana, Sagar, Pathar Pratima and Mathurapur Police Stations. Such brackish water fisheries are locally known as 1 bhasa-bada', 'nona-bheri' or 'nona gheri' fisheries. In this region paddy-cum fish culture is another popular form .of brackish water fish culture in which both paddy and fish are grown side by side. This system has developed from the long standing experience of the local people. A considerable portion of this deltaic region has been reclaimed for agriculture with the help of a series of earthern embankments, with sluices encircling the banks of rivers and creeks. In this system, the shallower plots are kept for fish farms and the higher plots are used for paddy culture. Three types of brackish water fisheries are common in this region, viz.,

i) Nona-gheri fish farm ii) Nona-gheri paddy-cum-fish farm iii) Nona-gheri fish-cum-paddy farm.

There are innumerable blind creeks and canals in Sundarban area which may be converted to nona-gheries by constructing cross-embankments and sluices for letting tidal water in and out to trap the fish. Thus extensive areas which otherwise would remain unproductive may be utilised for fish production. Some common indigenous varieties of fish found in the paddy fields and nearby bils, jheels and canals during monsoon are Punti (*Barbus spp*.), Chela (*Qxygaster spp.),* Chanda (*Ambassis spp*.), Mangur (*Carius batrachus*), Singi (*Heteropneuster fossilis*), Tangra (*Mystus spp*.), Pabda (*Ompok spp.),* Koi (*Anabas*

testudineus), Bele (*Glossogobius giuris*), Bhetki (*Lates calcarifer*), Lata (*Channa punctatus*) etc. But due to their slow growth rate and high feeding habit, these --varieties are considered less economic. So they are not usually cultured due to low out-turn.

III. Tiger Prawn Culture - The estuarine tract of West Bengal is fortunate enough having good supply of large quantities of seeds of tiger prawn during April-August. However, surveys carried out by CIFRI shows that tiger prawn seeds are available throughout the year though in varying quantities in some tidal rivers of this estuarine tract. Prawn seed banks have been set up to reduce the mortality of seeds and keep them in sound condition. But presently the seed banks are not in a position to assume the continued supply of prawn seed for prolonged period.' It is found that, in general, the bigger and better quality of shrimps are found in the first crop of the season, while the second crop is poorer in quality and yield is also lower. An assured supply of the required quantity of good seed is needed to increase its overall yield per hectare. For that purpose, it is necessary to have prawn seed hatcheries. India has now two modern commercial hatcheries for tiger prawn, established by Marine Products Export Development Authority. Prawns require specific types of feed for different larval and post-larval stages for optimum growth. Some of the feeds are biological. One such zoo-plankton is rotifers. But the feed for post-larval period are to be prepared by the farmers in their ponds. Research and experiments are going on for the preparation of feed with high feed conversion ratio. But the entrepreneurs prefer imported feed than to face risks in raising them in hatcheries.

IV.Inland Fishing Inland fresh water pisciculture is practised in South 24-Parganas District not only in the local rivers but also in numerous tanks or ponds and other water bodies. These fresh water fishes have a very good market in Calcutta and adjoining areas. Often it is found that the supply of such fresh water fishes fails to meet the growing demand. So there is much potentiality for the development of this resource.

V.Fishing in Rivers - Fishing in the rivers, particularly in the Hooghly river is gradually losing importance, due to various natural and man made hazards. Amongst the rivers in the estuarine tract, the Hooghly in the extreme west and the Ichamati, Kalindi, and Harinbhanga in the east carry most of their fresh water from upstream region. All the rivers in the southern part of the District are tidal in nature, thereby during high tides they are subjected to ingression of saline water rich in fish juveniles or fingerlings of Tiger shrimp (Penaeus

monodon), Penaeus indicus, etc. Supply of various other brackish water varieties like Liza parsia, L. tade, Mugil

Plate 130- Fishing in Burul , South 24 Parganas 22°21'41.56"N 88° 6'16.25"E

Plate 132– Fishing is done in Dakshin Raypur, 22°23'32.84"N 88° 7'51.32"E

Plate 133– Fishing is done near Achipur
22°28'4.70"N 88° 7'29.39"E

Plate 134– Commercial Fishing in Ganga Sagar , 21°37'59.91"N, 88° 4'31.92"E

Plate 135- Fishing for subsistence in Ganga Sagar , 21°38'17.92"N 88° 3'46.80"E

Plate 136 – Tiger Prawns , Namkhana Fishing Port 88°13'57.47"E 21°45'44.97"N

Plate 137- Sorting of fish in the Fish Trawlers, Namkhana, 21°45'48.48"N 88°13'53.05"E

cephalus etc. is sufficient. The catch of hilsa **(Hilsa ilisha)**, one of the most favoured deep sea variety, which forms various mouth-watering dishes of typical Bengalees, is gradually declining with the passing of years owing to enviromental hazards. Choking up of the rivers due to higher rate of sedimentation, occasional drought condition leading to lesser supply of fresh water, construction of dams and barrages in the upstream zones, water pollution due to industrial waste are some of the causes leading to decline in fish production in these rivers.

VI. Fishing in Impounded Water Bodies - The huge number of impounded water bodies available in South 24-Parganas District, if utilised properly will help effectively to raise the production of fresh water varieties of fishes which are of high demand in inland market. But unfortunately various political and socioeconomic factors stand in the way of economic use of these water bodies particularly in rural areas.

VII.Fishing in Beels, Baors and Marshy Lands - In the northern part of this District, there are several marshy tracts locally known as *beels* and *baors*. These are typical features in moribund delta region, caused by accumulation of rain water in depressions formed in between two river channels and also in the beds of derelict river beds. Baors are generally described as abandoned courses of river, some of which retain connection with the main stream. But unfortunately these beels and baors are being progressively silted up and reclaimed for agricultural or settlement purposes, resulting in consequent decline in the supply of fish.

VIII.Commercial Aquaculture Various technologies are available for extensive, intensive and industrial aquaculture. The production levels recommended for extensive culture are two tonnes of fish and one tonne of prawn/hectare, for intensive culture, five tonnes of fish and four tonnes of prawn/ha and for industrial hi-tech aquaculture 25-50 tonnes of fish/ha/year and 8-10 tonnes of prawn/ha/year. But these levels have been achieved at research and demonstration levels. Industrial aquaculture, however, requires trained manpower, raw materials, inputs and finance and a well organised effort for product development and marketing. High-tech aquaculture, controlled systems, culture of feed, formulated feeds and cage culture have opened up new vistas in such enterprises. The major consideration is that aquaculture uses water as a medium and consumes oxygen and nutrients for growth. These wet-land reservoirs and other water bodies have been created for agriculture and irrigation system, flood control and other uses. These are also used for aquaculture. Therefore aquaculture is a byproduct of agriculture and irrigation systems. But due to good economic

returns it can support rural development and self employment programmes. It is interesting to note that the total income from fisheries is comparable to that of forests and further increase in income from this sector is expected.

Plate 138 - Fishing Port – Kakdwip, 21°52'1.39"N 88°10'28.31"E

Plate 139 - Dry Fish Farming , Ganga Sagar , Sagar Island , 21°38'8.29"N 88° 4'23.62"E

Plate 140 &1 41- Dry Fish Farming , Ganga Sagar , Sagar Island , 21°38'8.29"N 88° 4'23.62"E

Plate 142 &143 - Dry Fish Farming , Ganga Sagar , Sagar Island , 21°38'10.56"N 88° 4'27.26"E

Plate – Prawn sorting in Moushuni Island , Namkhana . Plate – In the evening fishes are served in the Bakkhali Beach

6.2C. Industrial Activities-

The district of South 24-Parganas has the unique salient features of proximity to the highly urbanized metropolis of Kolkata on the eastern sides as well as the virgin and beautiful natural environs of Sundarbans. The district can be categorized into three broad groups (i) the marshy riverine land of Sunderban (ii) The non-Sundarban rural areas and (iii) the Urban and Semiurban areas. As regard industrialization, the three noted area have contribution in the field of industrialization for the district. The vast rural area of Sundarban suffers from poor infrastructural and educational facilities which are great hurdles for industrialization. The whole area is prone to storms & cyclones during monsoon and agriculture is mostly monoculture. 89% people depend on agriculture. There is little impact by the presence of humble no. of large, medium and some small scale industries in the Sundarban area. The urban and semi-urban areas viz. Thakurpukur, Mahestala, Bishnurpur, Sonarpur, Baruipur which are adjacent to Kolkata has locational advantage for industrialization. Budge Budge I & II, Kulpee, Thakurpukur – Maheshtala Blocks of our study area falls under the Urban and Semi Urban Category.

a.Jute Textile Industry - Of the 10 jute mills of this District 9 are located at Budge Budge police station and one at Maheshtala which produce jute bags and jute textiles. Within Budge Budge police station, 2 are located at Budge Budge Municipal area, 2 at Birlapur, 2 at Bade Kalinagar and 2 at Joy Chandipur. These are mostly jute spinning and weaving mills. Only one mill at Birlapur, namely Birla Linoleums Ltd., manufacture linoleum and similar other products. Recently the jute mills are facing various internal and external problems related to labour unrest and sheer competition from other jute growing nations especially Bangladesh and finally the increasing loss of demand of jute bags and other products in the international market due to various substitutes. Therefore much emphasis should be given on diversification of jute products with modern technology. Therefore the scope for further expansion of jute textile industry is to some extent limited under the present situation

b.Cotton Textile Industry - The growth of cotton textile industry in this District is restricted mainly due to non-availability of raw cotton. But in view of large market demand, there is enough scope for the expansion of this industry in this District. Amongst the 6 textile units, two are located at Baruipur. Of these (ginning and bailing) one is spinning and weaving mill and the other one is engaged in bleaching and dying of cloth yarn. The cotton spinning and

Plate-Some existing Jute industries of Budge Budge . Both the industries still manufactures sacks, bags etc

weaving mill is located at Bishnupur, one printing unit is located at Gobindapur at Budge Budge police station, one knitting unit is located at Memanpur in Maheshtala P.S. There was one cotton ginning and bailing unit at Kakdwip under public sector, namely the West Bengal State Co-operative Marketing Federation Ltd. but due to lack of raw materials, this unit is now closed. To augment the local supply of raw cotton, experiments are in progress for producing cotton in this District. However, the success of cotton cultivation in this District is still uncertain.

c. Major Engineering and Allied Units - The major engineering units of the District are mostly concentrated at Budge Budge and Maheshtala areas, though some units also occur at Sonarpur, Baruipur and Bishnupur areas. Out of 20 engineering and allied units 9 are found in and around Maheshtala. These units manufacture metal chain, switchgear, pumps, internal combustion engines, chemical machineries and other engineering products including one casting and forging unit. Of the 4 engineering units at Budge Budge, one is casting and forging unit, one textile machinery, one filtration, and distillation equipment manufacturing unit. There is one power-driven pump manufacturing unit. In Bishnupur there is one structural and metal products manufacturing unit and one producing various engineering parts and accessories. Such type is also found at Baruipur. In Sonarpur there are one tool making unit namely the Hindustan Small Tools (P) Ltd., one chemical machinery manufacturing unit and one wagon repairing unit of Calcutta Port Commission. Such engineering units being very much skill-oriented are found to be concentrated in the neighbourhood of Calcutta. There is good prospects of engineering units producing pump sets, agricultural equipments, machineries, grain grinder and oil crusher. Because the economy of this District is mainly based on agriculture and allied activities, proper infrastructure, tax and other benefits should be provided by the Government so that industrialists become interested in the manufacture of these products.

Agro-based Industries Amongst the agro-based industrial group, food processing, Bakery products, biscuit, fruit processing like jam, jelly, pickle manufacturing, vegetable canning, processing of cereals and pulses, oil milling both vegetable and mustard oil etc. are important. As such, there is fairly good scope for sunflower oil and rice bran oil production based on local raw materials. Besides these palm candy, sugar candy, sweet meat, moa prepared from puffed paddy, coir and coir products, jute rope, jute stick, straw board, spice powder etc. have good prospect. The major centres of developing these types of industries are

Sonarpur, Baruipur, Bishnupur, Mathurapur, Diamond Harbour, Budge Budge, Namkhana, Kakdwip, Canning, Basanti etc.

d.Forest-based Industries - The scope for developing forest based industry in this District is to some extent limited due to restrictive approach of Indian Forest Act. In fact, presently much emphasis is being given on conservation of the existing forests rather than on its commercial use. This is totally meant for the maintenance of ecosystem. In South 24-Parganas the Sundarban forest provides adequate resources for developing forestbased industry particularly those which can be developed based on minor forest products. In this District, the forest based industries like plywood making for tea chest and board, packing boxes, match stick, brush handle, wheel for bullock carts etc. furniture, boat, toys, electric switch board, bee keeping for honey and wax, etc. can be developed on the resources of the mangrove forest. The viable growth centres for these industries are Kakdwip, Namkhana, Kulpi, Diamond Harbour, Budge Budge, Maheshtala, Falta.

Over the past few years **Budge Budge** has developed considerably in terms of lifestyle and infrastructure. With the ongoing projects like Calcutta Riverside, widening of the Budge Budge Trunk (BBT) Road and the starting of the 7.7 km Batanagar Flyover from Jinjira Bazar to Batanagar; the economy of this city is expected to get a major boost.

Budge Budge owes much of its importance to the port, oil storage and jute mills. Being close to Kolkata and on the shores of the Hooghly River makes it a strategic location for oil storage and is the biggest oil storage for the metropolis Calcutta with big PSUs like Petroleum Wharves Budge Budge under Kolkata Port Trust. BPCL, HPCL, IOC having large units there. Jute mills were the biggest employers in the area till they started falling sick. Prominent among them are New Central Jute Mill and Budge Budge Jute Mills. At their height before 1971 these jute mills used to employ thousands of workers (New Central Jute Mills has been said to have employed as many as twenty thousand people) but after the partition of India and the subsequent creation of Bangladesh, supply of raw materials for these jute mills decreased. This, along with failure of trade unions lead to the closing of most of these jute mills.

e.The Budge Budge Thermal Power Station set up by CESC in Achipur (named after a Chinese called Achhu saheb by the locals who had established a sugar cane unit there) is a major source of electricity for Kolkata and its suburbs. Maheshtala is a city and a municipality of the South 24 Parganas district in the Indian state of West Bengal. It is situated on the eastern banks of the Hooghly River. It is a part of the area covered by the Kolkata Metropolitan Development Authority (KMDA). In 2007, a London-based company allied with Bengali NRI to develop a mini township with the Maheshtala Municipality, for which 21.22 acres (85,900 m2) had been acquired near Nungi station. There was expected to be 2,240 middle income group flats in 44 buildings and improve the road infrastructure in the area. Apart from the Calcutta Riverside residential township, Chief Minister Mamata Banerjee had also announced in 2014 that Maheshtala would also get a 1,000-bed hospital to be developed by Apollo Hospitals and real estate major Hiland Group, a film city, sports academy and an international school conceptualized by cricketer Sourav Ganguly.

f.Batanagar is a neighbourhood of Maheshtala of the South 24 Parganas district in the Indian state of West Bengal. It is a part of the area covered by the Kolkata Metropolitan Development Authority (KMDA). Batanagar was established to start the first shoe factory in India by Czechoslovak industrialist Tomáš Baťa. The Bata brand was established on 24 August 1894 in Zlín, then in Austria-Hungary (now in Czech Republic). The company first established itself in India in 1931 by renting a building to start an experimental shoe production plant in Konnagar with 75 Czechoslovak experts. Jan Antonín Baťa then built up an industrial manufacturing city called Batanagar in 1934, as well as other factories in Delhi and Patna and elsewhere in India, employing more than 7,000 people. Later Batanagar became one of the bigger suburban cities near Kolkata. It is one of the places named after the multinational shoe company Bata. There is a plant of the Bata company here. The employees

mostly reside in Batanagar. Not only the Bata India Shoe factory, another very remarkable feature of Batanagar, is that shoe-making is a predominant cottage industry in Batanagar. Countless houses and families are dedicated to manufacturing shoes of various makes - leather, PVC, jute, etc. for some of the leading shoe brands in India. For example - Khadim's, SreeLeathers, Titas and Liberty which are some of the most renowned shoe makers in India, have outsourced a major portion of their shoe making process to the various entities in Batanagar. Every alternate home in Batanagar houses a small unit which is manufacturing shoes.

This feature was born out of necessity, as most of the families residing in Batanagar are dependent on the Bata factory for their livelihood, hence whenever the factory gets locked-out, these families are very severely affected. Hence shoe making from their homes has given them an alternate source of earning.

Shoes are manufactured in almost
every families of Batanagar

6.2D. Kulpi Economic Zone- Port-cum-industrial complex -

Comprehensively master-planned, the Kulpi Economic Zone will combine modern all weather port facilities, environment-friendly ship breaking yard, and an industrial park in a single integrated hub. Dubai-based DP World, world's third largest port operator, took over the greenfield Kulpi Port project as part of its acquisition of P&O in February 2006. The first phase will have a 450-metre quay. The second phase will add 450 metres of quay. DP World's partners in Kulpi Port are Indian firm MKJ Enterprises and the West Bengal Industrial Development Corporation (WBIDC). Sultan Bin Sulayem, chairman of Dubai World, has reaffirmed commitment to Kulpi Port. He said that Dubai World was committed to the Indian state of West Bengal's development and to being involved long term in the progress of the important Indian economy as part of its global growth strategy.

The construction of the minor port in South 24 Parganas will mean that 150,000 people living in 90 villages will face eviction, according to the Committee for protection of residential and farm land. There are more than 40 brick kilns, employing more than 18,000 people, spread over 60,000 bigha area. Besides, there are offices, a few thousand shops, cottage industries and small factories which will also face eviction. There are six gram panchayats in the area where the port is proposed to be set up. Most of the people of this area are agriculturists.

In January 2014, the Government of West Bengal gave its clearance for the development of a ship-breaking yard.

Plate – Kulpi Port Complex (Source Wikipepia)

6.2E. Brick Kilns-

The northern stretch of our study area, particularly in Maheshtala and Budge Budge Blocks there are innumerable number of clusters of Brick Kilns. Flexible norms, rules and regulation has provided the entrepreneurs enough room to set up kilns haphazardly on the point bars or upon the vacant land or annex to a market, where they want; either in a rural or suburban area. This is obviously a favourable opportunity for burgeon of kilns. The West Bengal Government has entitled the point bar kilns as 'Baluchar' kilns and the others as 'Danga' kilns There are some natural Point Bars in Maheshtala , Budge-Budge and Kakdwip areas. The younger alluvium (Khadar) are the best suitable for Brick formations. Beside that there are ready markets of Kolkata , Budge Budge and Diamond Harbour for the final products.

Some of the Clusters are –

a. Akra in Maheshtala area- 22°32'20.93"N 88°14'42.88"E

b. Achipur in Budge-Budge area- 22°27'53.98"N 88° 7'30.56"E

Plate – Brick Kiln in Achipur

c. Kulpee Area near Durganagar- 22° 4'30.40"N 88°13'34.81"E

d. Raichak - Area near Raychak Ferry Ghat- 22°12'34.86"N 88° 6'48.48"E

e. Kalinagar- Kakdwip area 21°52'17.44"N 88°10'11.94"E-

Plate – Brick Kiln in Kakdwip area

CHAPTER 7: DOCUMENTING ENVIRONMENTAL PROBLEMS

Our Study Area is the part of the vast Ganga plain where the delta building process is still very active or has just reached the mature stage. Here the land hardly rises to 5 metres above sea level in the north, i.e in the mature part of the delta, to one meter or so in the active delta region in the south which is a mesh of innumerable twisting rivers and tidal creeks separating numerous islands. The distributaries of the Ganga which criss-cross this land include the Hoogly, Bartala/Muri Ganga and Saptamukhi. They are fed by sea tides. Twice a day, sea water enters more than 100 km. Through these estuaries and inundates the low lying plains. The average temperature in the district varies from a maximum around 38°C to a minimum of around 13.5°C. The annual rainfall average 1800 cm, more than 75 percent of which comes during the monsoon. Nor 'westers from March to May and the Bay Cyclones from mid June to mid November ravage the land every year.

Out of the 10 Blocks, 5 of the northern Blocks of Study area have fertile Gangetic alluvium while 5 blocks have either saline or degraded alkaline soil. Thus in the major part of the district , with the problem of waterlogging in the 'basin like islands 'of degraged or saline soil coupled with poor irrigation facilities only mono cropping is generally practised by the farmers.

Apart from this , there are more than 3500 Km. of very old earthen embankments that are essential for the very survival of the islands. With its proximity to the Bay of Bengal the land is very much prone to the wrath of Bay Cyclones and tidal disturbances during the monsoon. The natural levee's, already weakened by lashing sea waves during cyclones; often give in to the tidal bores resulting in disastrous floods.

Environmental hazards affecting the Hugli estuarine islands can be identified into three broad groups such as atmospheric hazards caused by atmospheric processes (tropical cyclone, storm surge, and nor'wester), tectonic hazards caused by internal earth processes (earthquake and tsunami) and geomorphic hazards caused by the earth surface processes (coastal erosion, tidal ingression and sand encroachment).

The major natural environmental hazards (NEH) that affect the area are **Atmospheric, Tectonic and Geomorphic .**

Table Showing the Types of Hazards and their impact areas.

Hazard class/ Type	**Season of activity/frequ en cy/rate**	**Impact on cultural landscape**	**Regions affected (with relative importance 5 point scale, A-E; E=least significant, A=most significant)**				
			Sagar	**Ghoramara**	**Jambu**	**Chuksar**	**Mahisani**
Atmospheric - Tropical Cyclone	April-May and OctoberNovemb er with maximum frequency in August.	Storm surges may cause inundation of the entire islands. The event may causes lose of land, agricultural products and other properties of the islanders	Coastal areas in general but interior areas may also get affected in high magnit ude events (A-D)	Coastal areas in general but interior areas may also get affected in high magnitude events (A-D)	Whole island (A)	Whole island (A)	Coastal areas in general but interior areas may also get affected in high magnit ude events (A-D
Tectonic- **Earthqua k e and Tsunami**	Approximately once in a century	May cause tsunami and subsidence resulting in transgressi on	Whole island (A)	Whole island (A)	Whole island (A)	Whole island (A)	Whole island (A)
Geomor phic- Coastal erosion	During monsoon seasons (JuneSeptemb er) and during tropical cyclones	Damages earthen embankm ents, erodes away marginal settlement s	Souther n part of the island mainly (A)	Whole island (A)	North-east and northw est part of the island mainly (D-E)	Southe ast part of the island (A)	Whole island (A)

Geomorphic- Salt water intrusion	Occurrence same as above	Inundates marginal farmlands, pond water became salty, may cause agriculture problematic	Souther n part of the island mainly (A)	Whole island (A)	Whole island (A)	Whole island (A)	Whole island (A)
Geomorphic- Sand encroachment	During late premonsoon season (April-May)	Covers farmland by windblown sands and may create problem in coastal settlements also	Areas adjacent to Coastal dune belts (C D)	Nonaffected	Areas adjacent to Coastal dune belts (C D)	Nonaffected (E)	Nonaffected (E)

Apart from the above mentioned problems , according to some experts , **Sea Level Rise** is also a major threat to this area. The IPCC (Intergovernmental Panel on Climate Change) in its 4th Assessment report, 2007, have found sea level rise a serious risk in coming decades. According to the report, "Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events..." Hazra et al. (2002) has reported the average rate of sea level rise as measured from the tidal records at Sagar point **is 3.14 mm per year**, which is higher than the global average of **2 mm per year**. The study used tide-gauge data with a span of 14 years. Another study by Nandy and Bandyopadhyay (2011) reported increasing trend of sea level rise inside the Hugli estuary at 0.10 ± 0.01 mm yr-1 km-1 denoting a positive relationship with the distance from the sea However, effects of sea level rise on the transient nature of the Hugli estuarine islands are not perceptible.

7.1.ATMOSPHERIC HAZARDS - TROPICAL CYCLONES

The destructive action of a tropical cyclone is mostly felt on the right of its track (northern hemisphere) and on the shores that face an advancing system perpendicularly (Coch,1994). It is an adverse combination of factors like lowest pressure attained by a storm, local sea level and tidal conditions at the time of its landfall that determines the surge level at a particular locality (Flather & Khandker, 1993).Thus, while the storm frequency diagrams and recurrence intervals do provide an approximate guide for frequency of the events, they do not necessarily mean recurrence of similar levels of destruction.

CASE REPORTS: The estuarine islands have faced severe cyclonic storms during the last three hundred years.

The event 1680: In 1680 a cyclone passed over the Sundarban including the Sagar island. It affected tremendously the whole island which was inundated by wave flows and great loss of life occurred.

The event 1737: Gentleman's Magazine of 1738 explained a graphic account of this calamity: "On the 30th September last happened a furious hurricane in the Bay of Bengal, attended with a very heavy rain which rained 15 inches of water in 5 hours, and a violent earthquake which threw down abundance of houses; as the storm reached 60 leagues up the river, it is computed that 20,000 ships, barks, sloops, boats, canoes etc., have been cast away. A prodigious quantity of cattle of all shorts, a great many tigers, and several rhinoceroses were drowned; even a great many caymans were stifled by the furious agitation of the waters. Two English ships of 500 tons were thrown into a village about 200 fathoms from the bed of the river Ganges, broke into pieces and the people drowned pell-mell amongst the inhabitants and cattle. Barks of 60 tons were blown two leagues up the land over the tops of high trees. The water rose, in all, 40 feet higher than usual. A french ship was drove on shore and bulged. After the wind and water abated, they opened the hatches and took out several bales of merchandize, etc., but the man who was in the hold to sling the bales suddenly ceased working, nor by calling him could they get any reply. On which, they sent down another, but heard nothing of him, which very much added to their fear, so that for some time no one would venture down. At length, one hardier than the rest went down and became silent and inactive as the two former to the astonishment of all. They then agreed by lights to look down into the hold, which had a great quantity of water in it, and to their great surprise they saw a great alligator starting as expecting more prey. It had come in through a hole in the ship's

side, and it was with difficulty that they killed it, when they found the three men in the creature's belly".

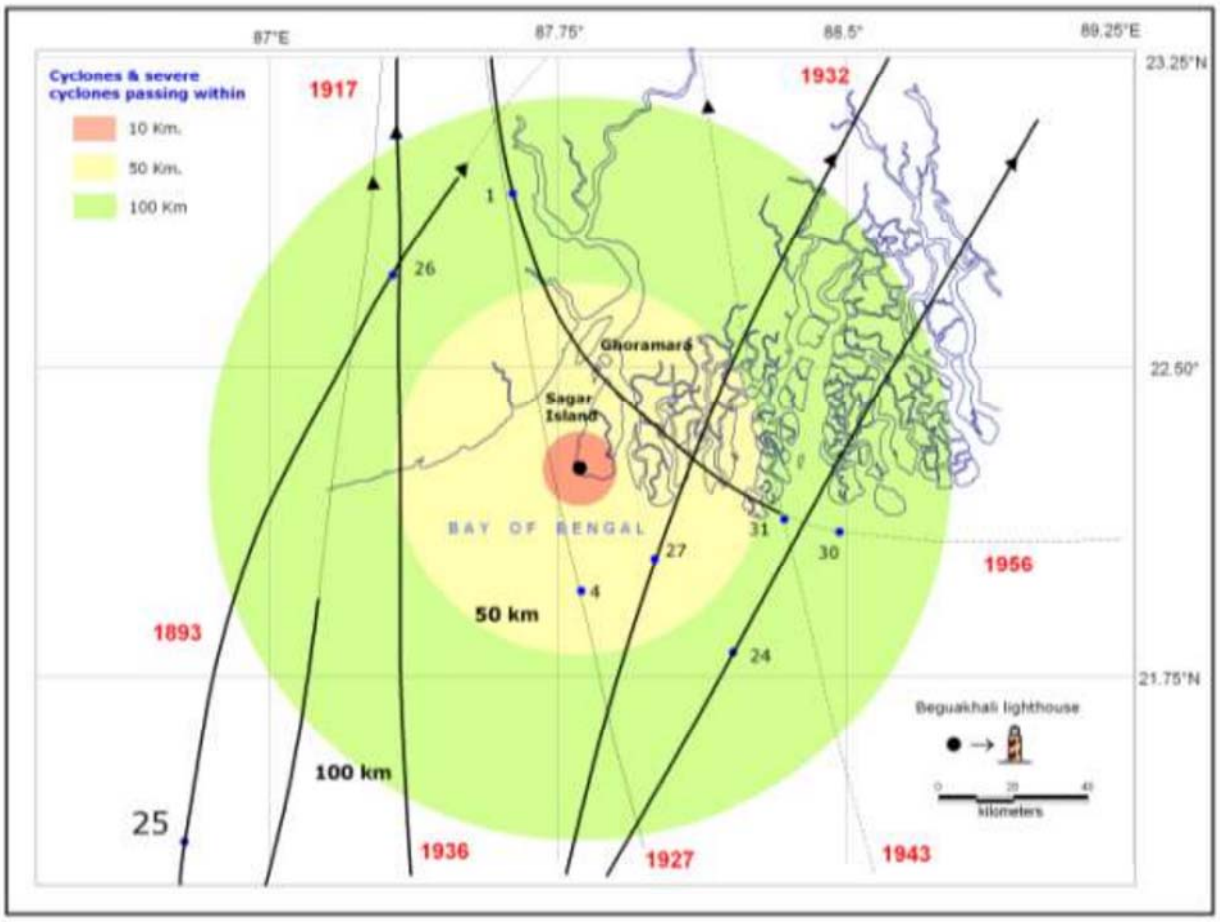
The event 1833: Blanford (1877) stated that the cyclone had crossed Sagar island on 21st May. The island was submerged to a depth of 10 feet, and the whole population of 3,000 to 4,000 was said to have perished. On this occasion an East India man, the Duke of York, was carried into the rice fields at Falta and left there high and dry.

The 1864 event: It was the most disastrous one. The height of the 1864 surge was greater than the 1833.The storm had been travelling up the Bay of Bengal in the day time of 4th October. It made itself felt at the sand heads on the afternoon and attained its full fury in the night. On 5th October the cyclone (originated in the north west of Andaman) and the associated storm surge "swept across the island with great force and wrought great havoc" (Pargiter, 1934).

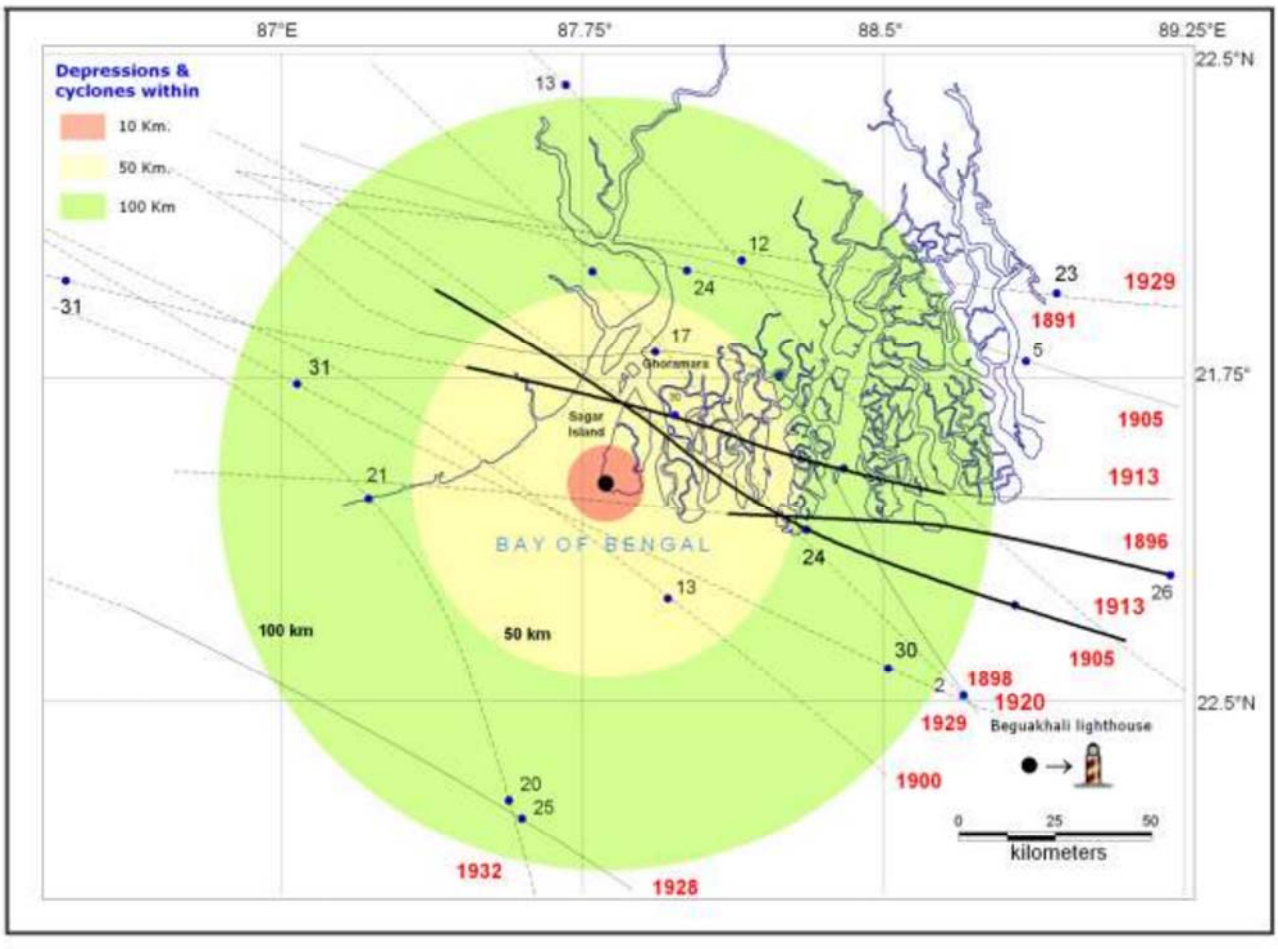
The 1977 event: On 11th September a severe cyclonic storm had passed over Sagar. The maximum wind velocity reached 130-148 km hr-1 (Pant et al., 1978). The cyclone had caused devastating disasters in coastal parts of West Bengal and Orissa. Pant et al. (1978) have 12 reported that about 40 persons (might be more the actual figure) and 4,000 cattle died due to this disaster.

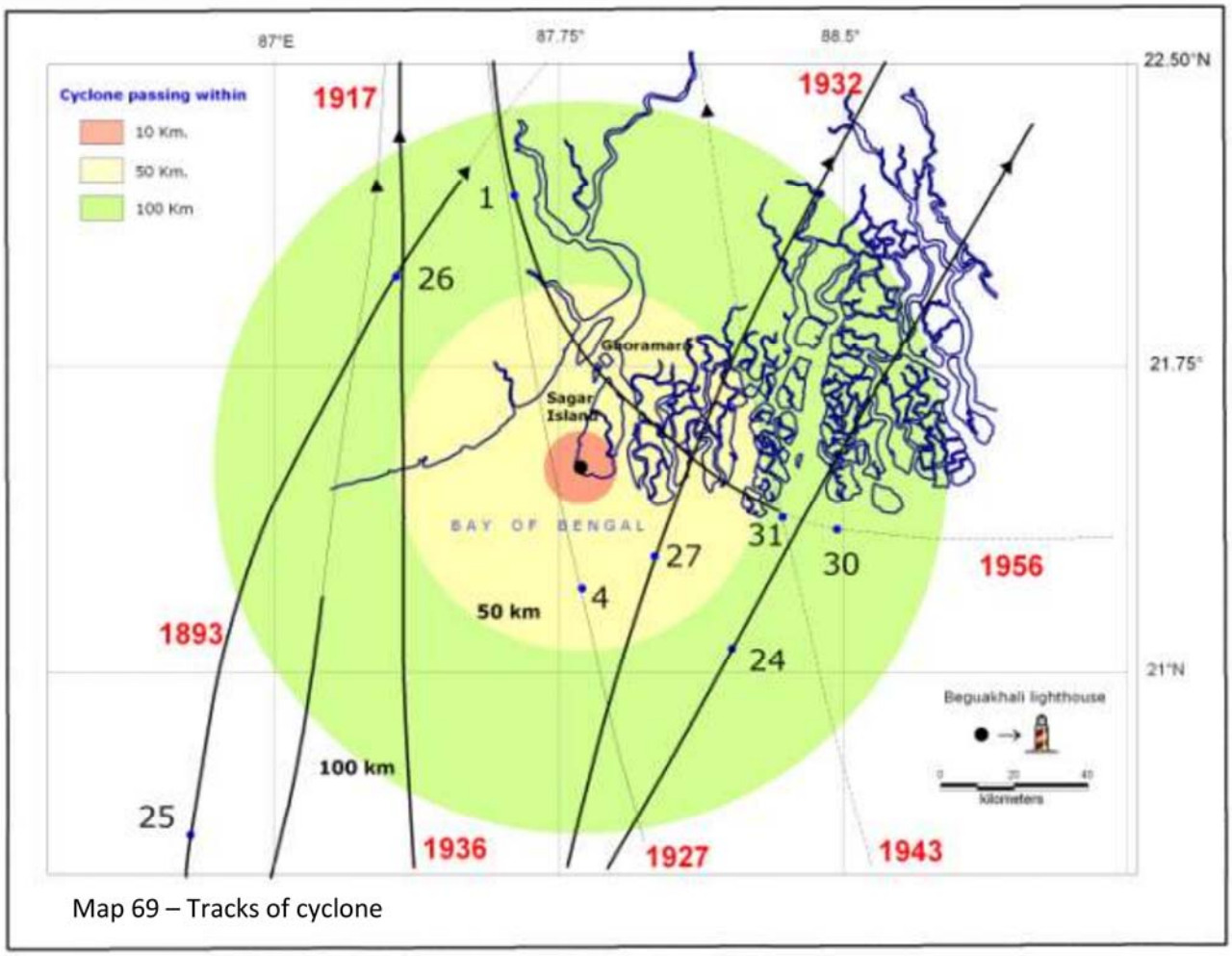
The 1988 event: The cyclonic storm of 29th November brought widespread damage to the coastal Sundarban including Sagar island (De and Bose, 1991) killing some 30 persons in the coastal areas of South 24-Parganas and Medinipur districts.

The 2009 event: The severe cyclone Aila has crossed Sundarban on 25th May, 2009. The wind velocity was 110 km hr-1. The heavy rainfall, strong wind and storm surge are the disastrous weather associated with cyclone. It continued to move in a northerly direction across West Bengal .According to media report, the state chief secretary has put the number of storm affected people at 2.2 million. More than 61,000 houses collapsed, more than 1, 32,000 houses were partially damaged and 100 people lost lives due to Aila. The entire Sundarban biosphere reserve area of 9,600 km2 has suffered extensive damage under the impact of AILA (Severe Cyclonic Storm, AILA: A Preliminary Report, IMD, 2009). Sibpur and Dhablat areas of Sagar island were severely affected due to Aila.



Map 67- Track of cyclone & severe cyclone Map 68-Track of Depression and Cyclones





Map 69 – Tracks of cyclone

Cyclone Amphan , Radar Image

November , 2019 - Very Severe Cyclonic **Storm Bulbul** was a strong and very damaging tropical cyclone which struck the Indian state of West Bengal as well as Bangladesh in November 2019, causing storm surge, heavy rains, and flash floods across the areas.. After crossing the Indochinese Peninsula, Severe Tropical Storm Matmo's remnants entered the Andaman Sea. It began to organize over the southern Bay of Bengal in the beginning of November, then it slowly intensified into a cyclonic storm as it moved north. In addition, it is only the second to make it to hurricane strength, the first being in 1960 and also the first severe cyclone that struck West Bengal after 1891.

March 20, 2020 – One of the most deadliest cyclone, **Amphan** hit the Bengal Coast with a speed of more than 190km/hour . Super Cyclonic Storm Amphan (/ˈɑːmpɑːn/) was a powerful and deadly tropical cyclone that caused widespread damage in Eastern India, specifically West Bengal, and also Bangladesh in May 2020. It was the strongest tropical cyclone to strike the Ganges Delta since Sidr of the 2007 season and the first super cyclonic storm to have formed in the Bay of Bengal since the 1999 Odisha cyclone. It was also the third super cyclone that hit West Bengal since 1582, after 1737 and 1833, as well as being the strongest storm to impact the area. Causing over US$13 billion of damage, Amphan is also the costliest cyclone ever recorded in the North Indian Ocean, surpassing the record held by Cyclone Nargis of 2008.

Cyclone Amphan made landfall in the Sagar Island , Shibpur Dhablat Mouza in West Bengal at 2:30 p.m. IST on 20 May, buffeting the region with strong winds and heavy rains . Although the extent of fatalities was less than initially feared, the cyclone's effects were nonetheless widespread and deadly. South Bengal , the epicenter of the cyclone's landfall, saw the most widespread damage from Amphan. The storm was considered the strongest to hit the region in over a decade. The state government estimated that the storm caused at least □1 trillion (US$13.2 billion) in damage and directly affected 70 percent of the state's population. Chief Minister Mamata Banerjee described the storm's effects there as worse than that of COVID-19. An estimated storm surge of 5 m (16 ft) inundated a wide swath of coastal communities and communications were severed. The greatest inundations were expected in the Sundarbans, where flooding could extend 15 km (9.3 mi) inland. Embankments in the region were overtaken by the surge, leading to inundation of the islands in the Sundarbans. Bridges linking islands to the Indian mainland were swept away. The cyclone

produced sustained winds of 112 km/h (70 mph) and gusts to 190 km/h (120 mph), which were recorded by the Alipore observatory, Kolkata, West Bengal, damaging homes and uprooting trees and electric poles. Wind speed along coastal areas were measured up to 150–160 km/h (93–99 mph). In Canning a wind speed of 157 km/h (98 mph) with gusting up to 185 km/h (115 mph) was recorded, while nearby Nimpith and Sagar Island observed 155 km/h (96 mph) and 111 km/h (69 mph) wind speed. TheNetaji Subhas Chandra Bose International Airport recorded wind speeds up to 133 km/h (83 mph) .This overturned vehicles and snapped approximately 10,000 trees. The Calcutta Municipal Corporation stated that Amphan toppled over 4,000 electric poles, leaving much of the city without power for over 14 hours. At least 19 people were killed in Kolkata. The storm also triggered widespread flooding around the city. 236 mm of rain was recorded in Kolkata.

Downed power lines caused power outages across West Bengal, prompting CM Banerjee to order power supplies to be cut in the two states of 24 Parganas as a precautionary measure. Thousands of mud homes were damaged in the entire strtch. A million homes were damaged in Sagar Island , Namkhana , Kakdwip , Diamond Harbour blocks and breached embankments led to the flooding of villages and swaths of cropland. Saltwater inundation affected surrounding areas following damage to 19 km (12 mi) of nearby embankments. Across West Bengal, 88,000 hectares (217,000 acres) of rice paddies and 200,000 hectares (500,000 acres) of vegetable and sesame crops were damaged.

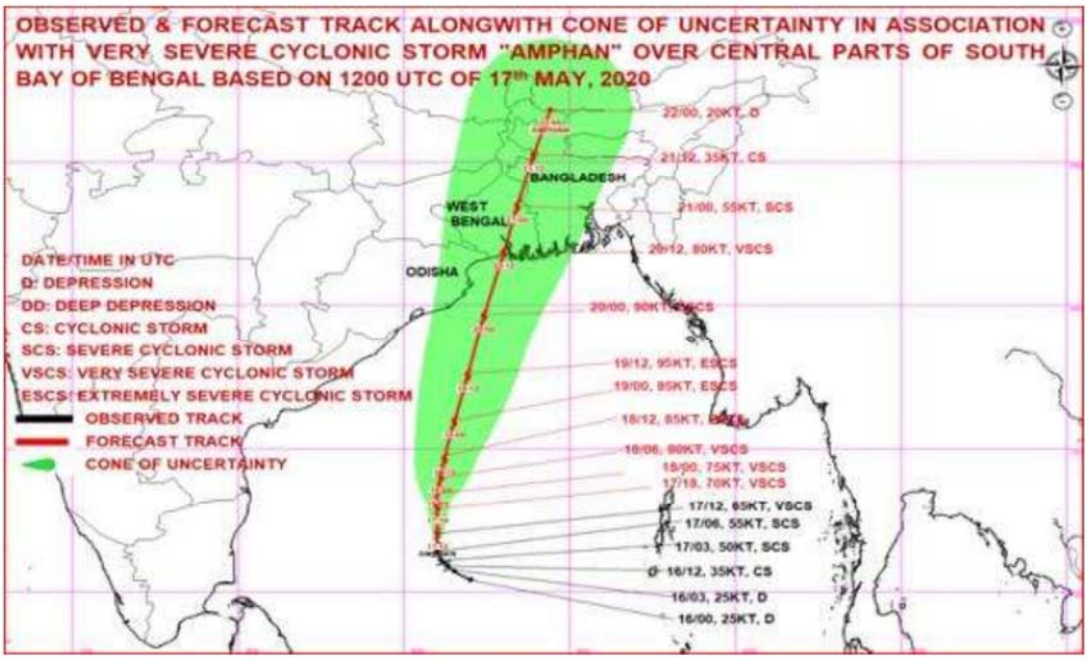


Plate 146– 26th March , 2020. All the shacks, shops, trees were uprooted in the Ganga Sagar Beach after the catastrophe.

Plate 147- With the combined power of three hurricanes and believed to be West Bengal's fiercest cyclone in decades, Amphan's rage has left an irreparable damage on the ecological fragile Sundarbans region and its people in South and North 24-Parganas.

Plate 148– 26th March , 2020 . This photograph was taken in Shibpur Boatkhali Mouza of Sagar Block where the Landfall of Amphan occurred on March 20th , 2020 at 2pm. This stretch had a village which has been completely wiped off from the surface. The entire configuration of the Island has transformed.

Plate 149 – Devastated Ganga Sagar Beach , 26th March,2020

Plate 150– March 26, 2020 . Kochuberia Jetty got dismantled due to Cyclone Amphan, Source -

Plate 151–Saline water ingression in the agricultural field, Namkhana.

Plate 152 – Millions of people became homeless in South Bengal . Homeless people living beside the main roads. This photo is showing how people are living beside Kakdwip – Diamond Harbour Road.

Plate 153 – Almost all the Beetle Vine Plantation got destroyed in Sagar and Namkhana Block. All the farmers face a huge loss of money .

Plate 154 &155– Breached Embankment , Tidal Saline Water Ingression, Sumatinagar , Sagar Block . 21°42'27.11"N 88° 9'16.30"E

Plate 156- Broken Embankment in Eastern boundary Sagar island Plate 157– Uprooted Trees , Bakkhali Beach

Plate 158 – Ganga sagar Beach , Broken Beach Embankment

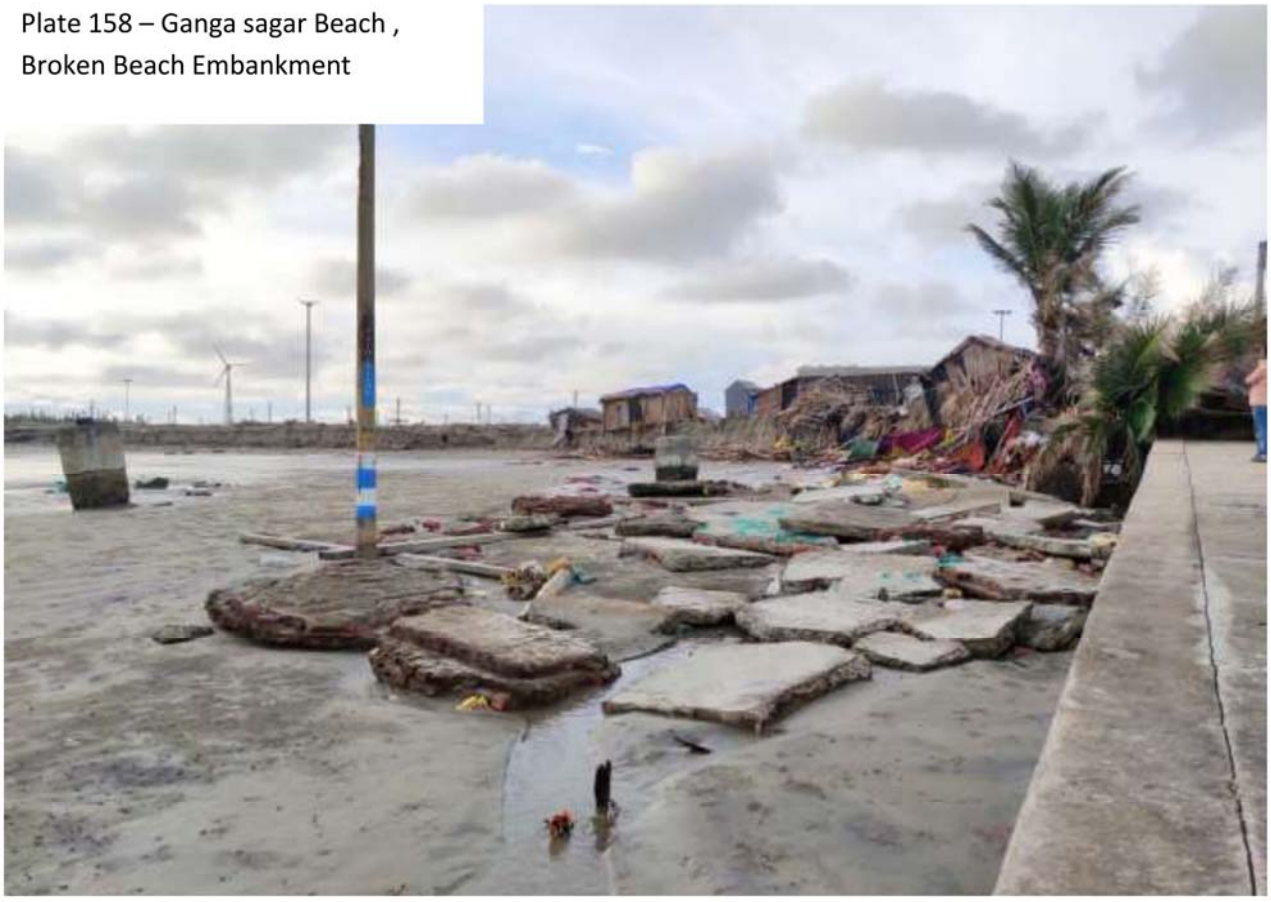


Plate 159- People fighting with tidal surge of Muri Ganga River, Bankim Nagar

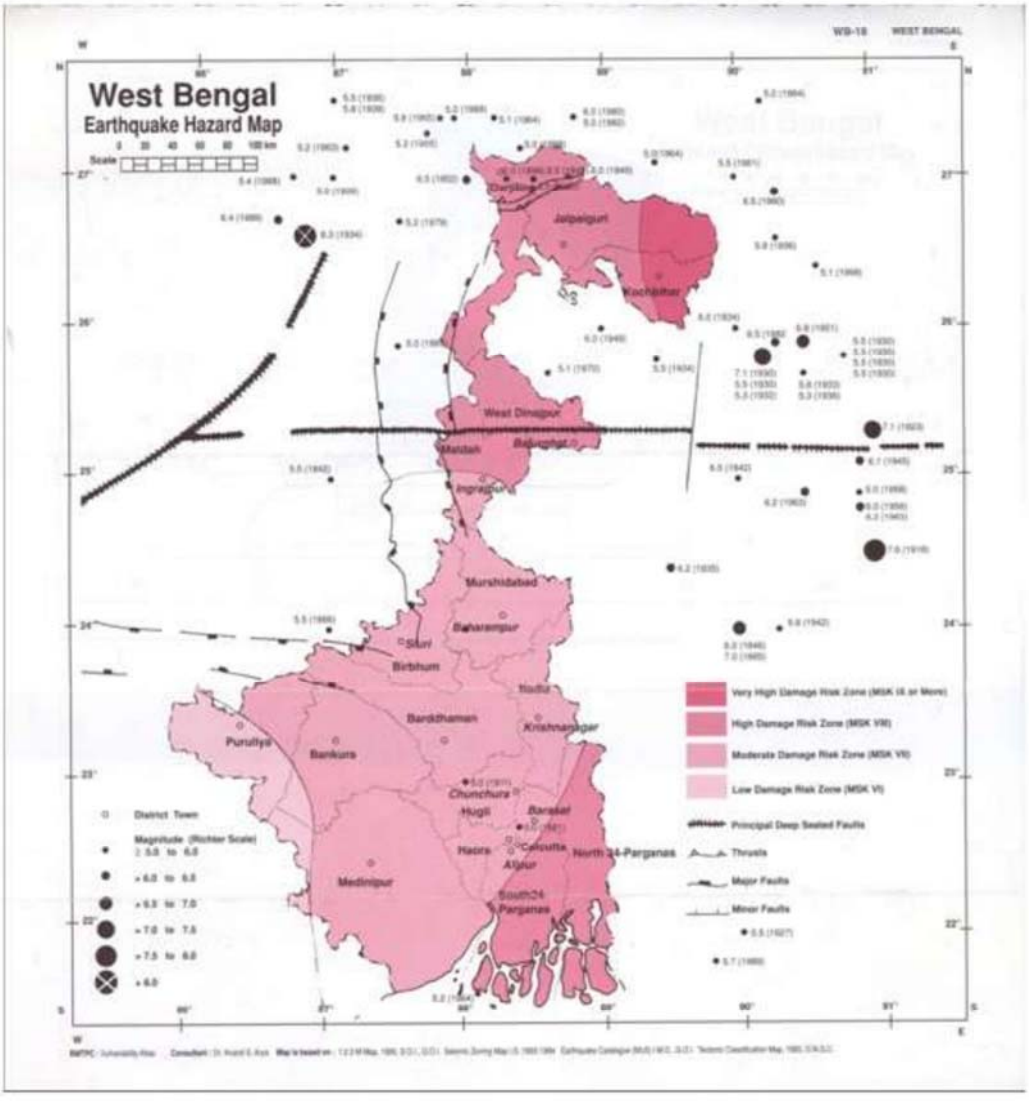
Plate 160– Broken Embankment , Baliary , Moushuni Island

Plate 161– Devastated beach of Baliara , Moshuni Island

7.2. TECTONIC HAZARDS

1. Earthquake In the estuarine islands of Sundarban, there are few areas of low seismic activity. Sagar had experienced earthquake on 12th October, 1737 (Gentleman's magazine, c. 1758-9 in Calcutta Review, 1859), in 1842, 24th August, 1858 (Calcutta Review, 1859), 11th July in 1885 and 12th June in 1897, without facing any significant impact because of low magnitude of the events. The largest instrument-recorded earthquake occurred on 15 April 1964, West of Sagar island (mb 5.2), which caused damages in West Bengal and Orissa (Amateur Seismic Centre, 2013).

2. Tsunami- Tsunamis are unlikely to pose a significant hazard in the islands of the Hugli estuary. As such, there is no report of damage in the region due to the catastrophic tsunami of 26th December 2004. However, any future offshore developments in the islands may be affected by tsunamis.

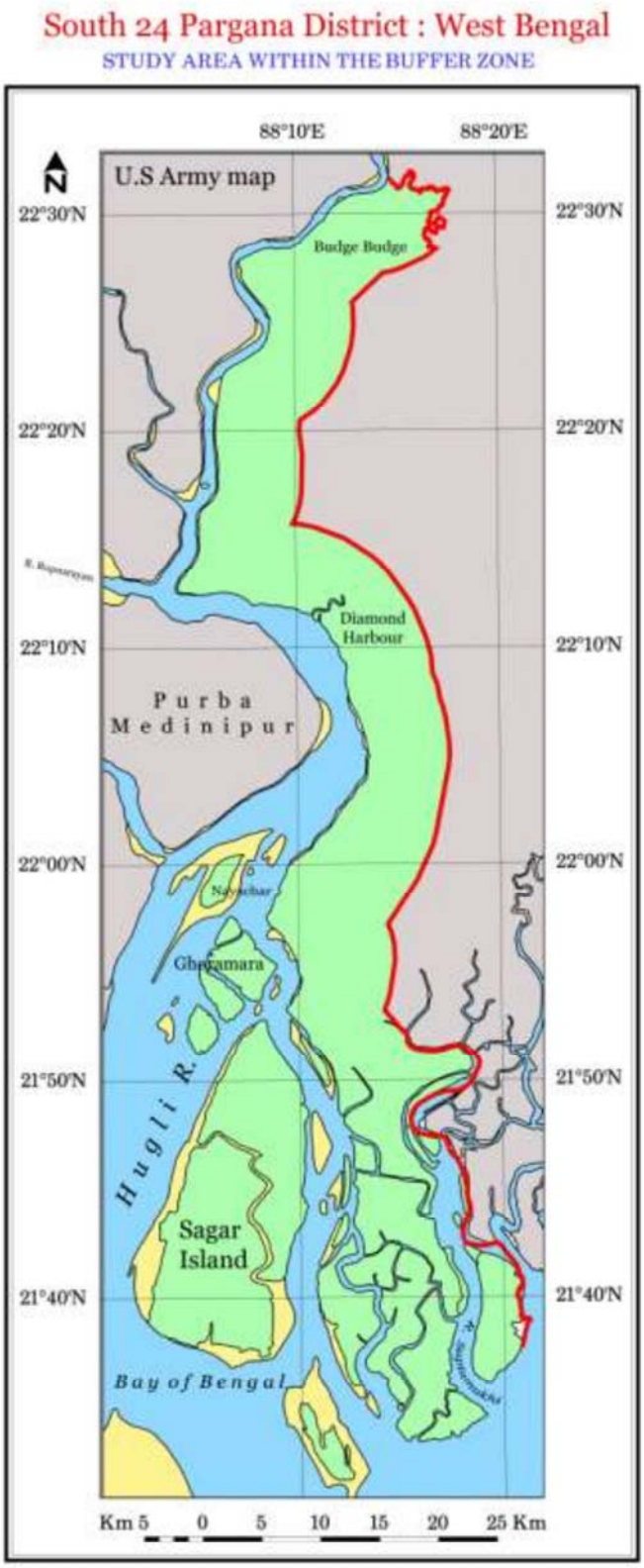


Map 70 – Earthquake Zones of West Bengal

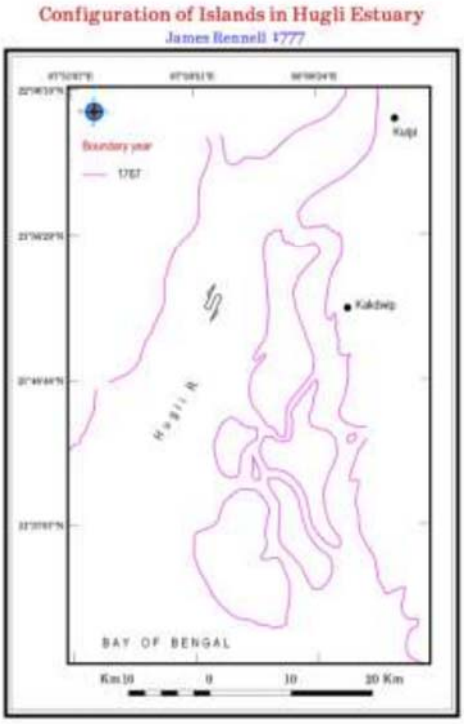
7.3. GEOMORPHIC HAZARDS –

A. Coastal erosion

One of the major Geomorphic Hazards of the Study area is Coastal Erosion. Overlaying of the the US Army Mp of 1950 on the present Satellite Image shows that the Island Part of the Study area has a remarkable change in the Shoreline. Sagar Block with Ghoramara Island is the worst affected. 29% of the 62 Km long stretch of the Sagar Island coastline got affected.



Map 71 – Caostal erosion , US ARMY Map



Map 72 – Sagour Island , from the James Rennell's Bengal atlas.

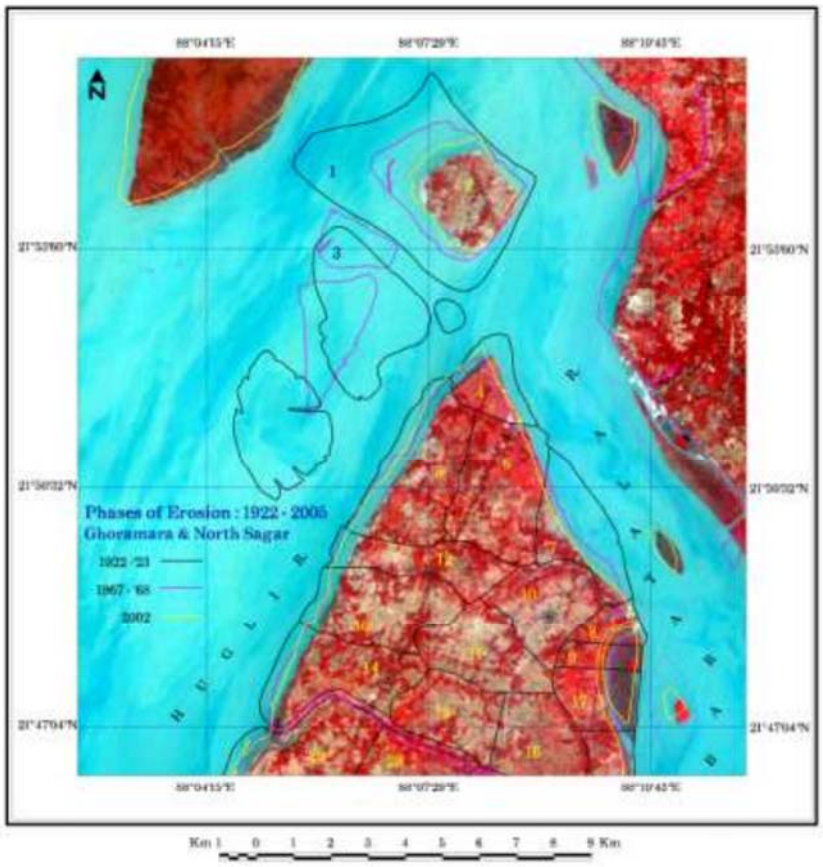
Rennell, began his survey of Bengal in 1764, became Surveyor General for the East India Company in 1767, and spent the next 10 years carrying out his survey of an area of about 3000,000 square miles, an area slightly larger than the state of Texas. The *Bengal Atlas*, first published in 1779, was the culmination of this work and was critical for commercial, military and administrative activities. Rennell's maps were the most accurate ones of the area for the next sixty years.

The degradation of Bhagirathi-Hugli system starts from last few centuries and the lower course is maintained by its right bank tributaries and tides. Apart from this flow it becomes dries up. For that reason **Farakka barrage** plays a vital role to divert certain amount of water from Ganga in 1975. Hugli estuary loses his importance with high rate of sedimentation and continuous change. Oscillation in thalweg and tidal sand ridges are responsible for such changes.

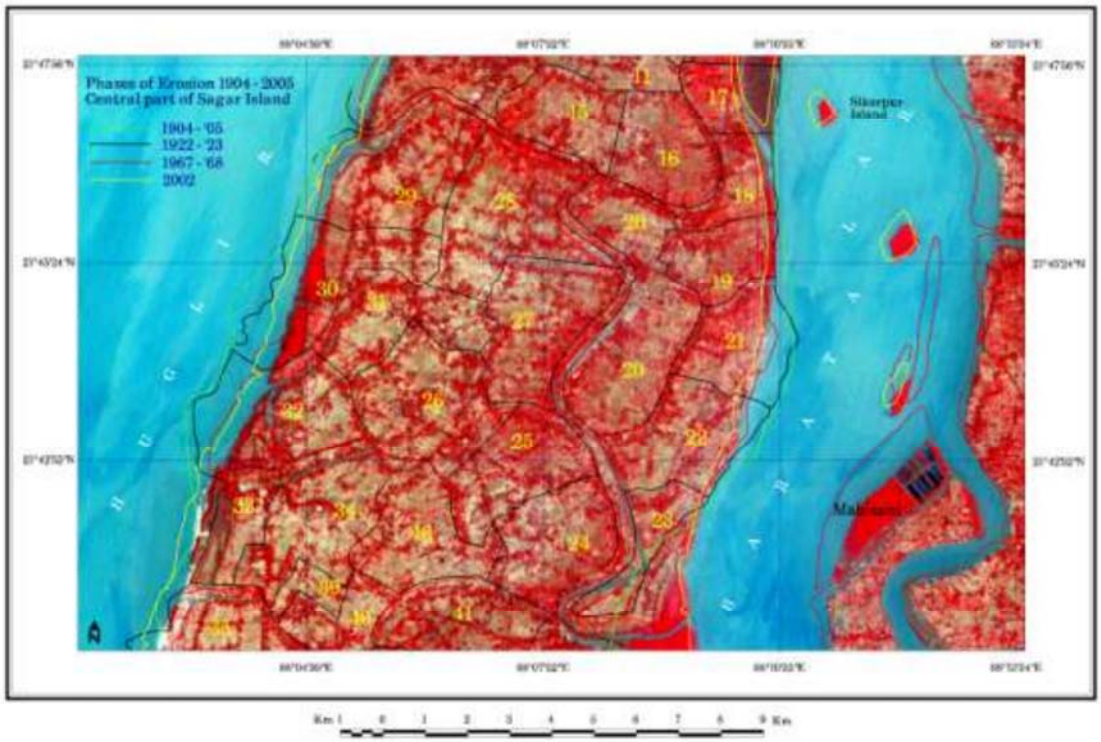
An estuary is responsive to the **change in sea level**. Apart from vulnerability to storm it has a great influence in estuarine sedimentation. The sea level increases during Holocene period. In between 1993 and 2003 due to thermal expansion of sea water, melting ice and effect of global warming sea level increases in rapid way (4mm year-1) which can be considered as a vital cause for coastal erosion. As coastal erosion is a common factor in this part so some of islands was initiated from the early 19th century by placing earthen embankments (O'Malley, 1911:130-141, 1914; Ascoli 191:76-79, Lahiri 1936:118-120).To accommodate huge population (775persons/km-2) mangroves have to replace along the entire stretch of islands. They have to change their livelihood with the changing pattern of the estuary.

However according to Prof.Sunondo Bandopadhya, Geography Department ,Calcutta University - Rapid erosion of the mangrove -dominated reaches of this part of the coast also confirms that coastal retrodradation here is not linked to deforestation (Bandyopathay and Bandyopathay, 1996). Periodic accretional phrases of the delta and the emergence and submergence of the small islands along the southern periphery can be ascribed to reworking of the erosional products and the other sediments by the delta's high energy environment. This is very common in most of eroding world deltas such as Nile (Carter,1988,p.483) However in the Hugli estuary, there are indication of slow progradation of the delta(Reas,1919;Hiranandani and Ghotanar,1961).

The evolution of Sagar island since the mid-nineteenth century clearly shows predominance of erosion that was unevenly distributed over space although it has progressed more or less steadily through time . The sequential changes of Sagar island shows that in 1776, the island was fragmentized. But in between 1851-1887, the shoreline of Sagar island was shifted and became detached from Ghoramara island. It can be found that from 1971 to 2015 the area of Sagar island decreases rapidly, mostly on the southern part of this island. In 1951 the total area of this island was 285 sq. km. which is falling down in 235 sq. km. in the year 2015 due to continuous rate of erosion. It means that from 1951 to 2015 the island losses a total of 60.62 sq. km. area. One important fact revealed from the 140-year chronological study is that coastal erosion of the island took place irrespective of its forested or deforested reaches. During the latter half of this interval (that is, the last 70 years), all except two of the 27 coastal Mouzas were affected by erosion and nine lost more than 25 per cent of their original extension . The Mouzas particularly affected were: Bishalakshipur , (area eroded: 96.1 per cent), Sagar (67.0 percent), Muriganga (60.9 per cent),Ramkrishnapur (57.1 per cent) and Shikarpur(55.7 per cent). The north eastern river-board Mouzas were the main corridor through which peopling of the island progressed and was major population centres right from its early reclamation years. Erosion of these mouzas increased the concentration of this population even more.



Map 73 – Sagar Island FCC , Landsat Northern Part



Map 74 & 75 – Image FCC , Sagar Island, central and southern part

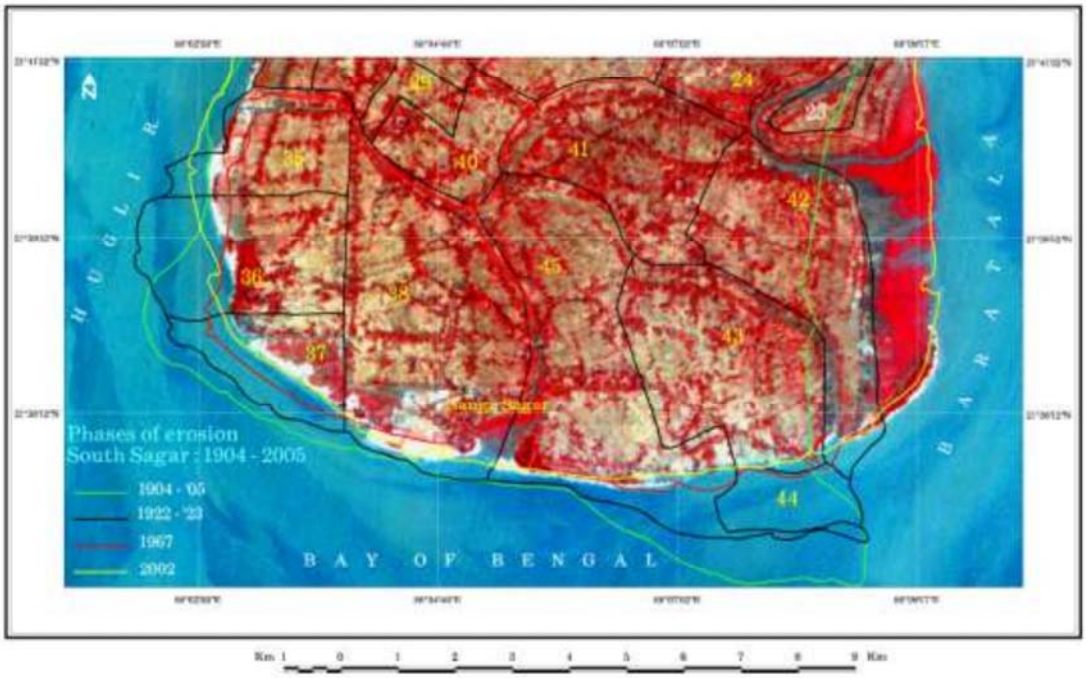


Plate 162 – Shibpur Boatkhali area in the South Eastern Coast. There is a huge coastal erosion in this part of the island 21°38'3.28"N 88° 7'15.94"E

Plate 163 – The entire habitation was wiped away leaving behind the Tulsi Mancha of some house

Effect of Coastal Erosion

a. Sedimentation: Tidal water enters into the inland at a higher speed and during ebb tide this water fails to go back seaward and the sediments which they entrain deposited into the channel. As a result the channel become filled up and going to decrease in depth. So siltation is the main problem in coastal area.

b.Increasing Salinity: Tidal influence plays an important role to increase the salinity. Tidal water enters into the island and the severe destructive wave action increases the salinity which has an adverse effect on socioeconomic conditions of this island, especially on the crop production. Only the plants which have a good salt tolerance can grow in this area. This type of water is not fit for irrigation and agriculture purposes.

c.Problems Of Ground Water: The problems of ground water is the another important sign of coastal erosion on Sagar island. This is mainly due to the ingression of sea water during high tide time. Several parts of the island become submerged under the sea water during high tide conditions which helps to percolate the saline sea water under the ground and contaminate the ground water. Besides construction of deep tube well for the irrigation purpose also help to pollute the ground water in this region

d.Loss of Land: Due to destructive wave action and tidal effect most of the areas are going to submerge under the sea. As a result of which people have to loss their property as well as land. Though the state govt. has taken the initiation to construct the embankment, but built up embankment is not a permanent solution to protect the island from landless.

Continuous erosion and land loss change the characteristics of the land and decrease the productivity in this area. Salinity remain increases rapidly, mangroves are degraded and sand deposited in the south eastern part of the island. Most of wetlands are effected by salinity during cyclone and embankment breaching. Besides these immense growth of settlement also helps to change the shape of map of this island.

7.3.2.Salt water Intrusion - Like other areas of the Sundarban, estuarine islands are also reclaimed pre maturely. Therefore, during storm surge and tidal ingression, salt water intrusion into the low-lying island areas is typical of all the islands. Intrusion of saline water into agricultural lands and ponds make life measurable to the islanders.

Plate 164– The effect of coastal erosion in Boatkhali – Shibpur area. Plate 165 – Ganga Devi's idol in the broken beach of Ganga Sagar.

7.3.B. Sand Encroachment

Encroachment of sands in agricultural lands as well as in residential areas acts as hazard to the inhabitants mainly in south-eastern part of the Sagar. It covers the cropping fields and occasionally destroys small huts making the livelihood difficult.

7.4. CLIMATE CHANGE AND VULNERABILITY

This coastal belt is arguably an object lesson on how people are coping with a rising sea. Considered sacred by Hindus because it sits at the confluence of the Ganga and the Bay of Bengal, this large island of 160,000 people is buffeted by the worst effects of climate change – coastal erosion, rising sea levels, unpredictable tidal surges, land salinity and more violent cyclonic storms.

There has been an increase in the intensity of cyclones making landfall in the Sundarbans between 1951 and 2020, recent research suggests. Such an increase in intensity may be attributed to an increase in **sea surface temperature**.

Between this period, it has been observed that the temperature of the waters in the Sundarbans has increased at an accelerated rate of 0.5^{o} C per decade compared to the observed global sea surface temperature warming at the rate of 0.06^{o} C per decade. This accelerated increase in temperature of the sea has severe implications on aquatic life. This change greatly impacts the Sundarbans area as it is an estuarine delta. Further, it detrimentally affects the health of the mangrove ecosystem.

Another direct effect of the climate change is the **rise in salinity** of the water. Impact on Agriculture Studies suggests that in the last two decades, the run off in the eastern rivers of Sundarbans has decreased resulting in ever increasing salinity and sea water-sulfate concentrations. The decrease in fresh water run off has affected mangrove growth. Further, agriculture is being affected because of the high levels of salinity of the soils due to high tides, cyclones and storm surges, and problems of water stagnation, sometimes even beyond monsoon seasons.